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REPORT

OF THE

MISSISSIPPI RIVER COMMISSION

SHOWING PROGRESS

FROM OCTOBER 1, 1884, TO JUNE 30, 1885,

BEING

APPENDIX W W 2

OF THE

ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1885.

Q. A. GILLMORE, Colonel of Engineers, Bvt. Maj. Gen. U. S. A.,
President.
C. B. COMSTOCK, Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.,
CHARLES R. SUTER, Major of Engineers, U. S. A.,
Mr. HENRY MITCHELL, Coast and Geodetic Survey,
Mr. B. M. HARROD, Civil Engineer,
Mr. S. W. FERGUSON, Civil Engineer,
Mr. ROBERT S. TAYLOR,

Commissioners.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

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~~W. 2185~~

Eng 1010.5

1893, Dec. 15.

Captain Earl Paisley,
St. Louis, Mo.

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[EXTRACT FROM THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS TO THE SECRETARY OF WAR.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITES STATES ARMY,
Washington, D. C., October 16, 1885.

* * * * * * *

MISSISSIPPI RIVER COMMISSION.

This Commission, organized under the provisions of the act of June 28, 1879, reports to and receives instructions from the Secretary of War through this office.

Information regarding the progress of the Commission in its duties was transmitted to Congress, as required by the above act, in a report dated December 19, 1884, which was printed as House Ex. Doc. No. 64, Forty-eighth Congress, second session.

* * * * * * *

The Commission also submitted to the Secretary of War, July 15, 1885, a report embracing the subjects and subdivisions specified below, viz:

1. Progress of surveys and examinations from October 1, 1884, to June 30, 1885.
2. Progress of construction from October 1, 1884, to June 30, 1885.
3. Plan and methods of improvement discussed.
4. The Atchafalaya Outlet.
5. Vicksburg Harbor.
6. Legislation recommended.
7. Financial statements and estimates of funds for the fiscal year ending June 30, 1887.

(See Appendix W W 2.)

* * * * * * *

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APPENDIX W W 2.

REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR 1885.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE,
New York, July 15, 1885.

SIR: The Mississippi River Commission has the honor to submit the following report, embracing the subjects and subdivisions specified below, to wit:

(1) Progress of surveys and examinations from October 1, 1884, to June 30, 1885.
(2) Progress of construction from October 1, 1884, to June 30, 1885.
(3) Plan and methods of improvement discussed.
(4) The Atchafalaya Outlet.
(5) Vicksburg Harbor.
(6) Legislation recommended.
(7) Financial statements and estimates of funds for the fiscal year ending June 30, 1887.

PROGRESS OF SURVEYS AND EXAMINATIONS.

The surveys and examinations undertaken in pursuance of the requirements of the third section of the act under which the Commission was organized have been continued.

In the last annual report, progress in this branch of work was noted to October 1, 1884. From that date to the end of the past fiscal year work has been accomplished in field and office as follows:

Gauges.—Daily readings have been taken and displayed at all stations previously established, up to the end of April last, at which time those at Cliff, Mo., Cottonwood Point, Mo., Mhoon's Landing, Miss., Saint Louis Landing, Ark., Saint Joseph, La., Port Hickey, La., and Plaquemine, La., were discontinued. A lack of funds made a reduction needful, and these were regarded as the least important or the most difficult to maintain in good order.

The reading of the gauge at Biloxi, established last season for the purpose of determining the mean level of the Gulf, ceased with June 10, 1885, a full year of observations being obtained.

Final topography and hydrography.—The survey of the river, with marginal topography, which at the date of the last report was complete from Cairo to the Gulf, and from Grand Tower to Devil's Island, was prosecuted from the latter point and completed to Hacker Towhead, about 25 miles farther, when cold weather put a stop to field work, and want of funds has prevented its further prosecution.

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Discharge observations.—Six parties, at as many localities, were kept in the field from the end of September, 1884, till early in April, 1885, when they were withdrawn because of lack of funds.

Preparation of maps.—Work on the preliminary chart (1 inch to a mile) has been continued. The complete series, comprising 32 charts, has been printed, excepting the index charts, now nearly ready. Nine sheets of the series on a scale of 1 to 20,000 are printed. The material is prepared for 30 others—all below Island 63—and for 28 others below Cairo is in course of preparation. The series on a scale of 1 to 10,000 will comprise 215 manuscript charts, of which 168 are finished, except titles, notes, &c. A map of the alluvial valley from Cape Girardeau to the Gulf, on a scale of 1 inch to 5 miles, of sufficient width to embrace the several basins of the lower river, commenced last year, is well advanced towards completion.

The following papers relating to the work of surveys and examinations are submitted as appendices to this report:

Appendix C.—Annual report of the secretary of the Commission.

(1) Report on field work of topography.

(2) Report on mechanical device for printing topographical signs, &c.

(3) Report on reduction of high and low water observations.

PROGRESS OF CONSTRUCTION.

At the date of the last report operations were being vigorously carried on, the amount available October 1, 1884, being over $2,000,000. The season was favorable for work until the middle of December, when severe cold weather caused operations to be suspended in all but the lower districts. Congress having adjourned without providing for continuing the improvement, all work was discontinued in the districts below Cairo except the compietion of contracts on levees. But little work has been done this season except in the district between the Illinois and Ohio rivers.

The general service continued the purchase of supplies and material and the delivery of stone till the close of operations. The present value of the plant used for that purpose is estimated at about $186,000. The expenditures during the time covered by this report were about $98,000, and were apportioned to the districts according to the service rendered. The balance available July 1, 1885, is about $128,000.

For details reference is made to the report of Captain Willard, Appendix D.

The present value of the construction plant now owned by the Government is $1,267,000, of which $1,215,000 is for floating property, and $52,000 for instruments, tools, and outfits. It comprises 14 steam towboats, 7 steam-launches, tugs, and survey-boats, 49 quarter-boats, 83 pile-drivers, 6 hydraulic graders, 1 dredge, 6 dump-boats, 2 pump-boats, 3 derrick-boats, 6 shop-boats, 5 docks and store boats, 19 mattress-boats, 2 ways, 8 screen-boats, 263 barges, 25 coal-boats, shells, and flats, 290 skiffs, yawls, and sounding-boats, 129 flats, shops on shore, movable buildings, tools, surveying instruments, gauging apparatus, safes, office furniture, and outfits. Detailed estimates of items and classification are given in the reports of the general service and of the officers in charge of districts.

During the year 30 barges were borrowed from the Missouri River Improvement, value about $50,000, and barges and tow-boats were chartered at various times for special service, the estimated value of which is placed at $250,000.

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WORKS ABOVE CAIRO.

DISTRICT FROM DES MOINES RAPIDS TO ILLINOIS RIVER, 161 MILES.

The general plan in this district consists in closing side channels by low dams, protecting banks subject to erosion by mattress and revetment work, and reducing the low-water channel to an approximately uniform width, so as to provide a navigable depth of 5 feet at low water.

The dredge is employed in this district to facilitate the action of dams or to remove temporary obstructions, the material excavated being used for foundations of brush-dams when suitable.

Operations since the last report have consisted in extending and raising the dams at Brokau Island, La Grange, and Bolter's Island, the construction of spurs, repairing works injured by rafts and ice, dredging in Quincy Bay, and through Wyaconda Bar, and building shore protection.

The present value of the plant used in this district is estimated at about $79,000. The expenditures during the period covered by the report were about $90,000, and the amount available July 1, 1885, is about $87,000. For details see report of Captain Ruffner, Appendix E.

DISTRICT FROM THE ILLINOIS RIVER TO THE OHIO RIVER, 241 MILES.

The object of this improvement is to obtain a minimum depth at low water of 6 feet from the mouth of the Illinois River to Saint Louis, and of 8 feet from Saint Louis to the mouth of the Ohio. The general plan contemplates making the improvement continuous, working down stream from Saint Louis, by reducing the river to an approximately uniform width of 2,500 feet, the natural width being in many cases from 1 mile to 1½ miles, and to protect the alluvial banks from erosion.

The methods employed are to direct the flow, and to build up new banks with solid material, caught from the river itself by means of hurdles, and to revet the new banks so formed, as well as the natural banks where subject to caving. Work is also done at detached points, when specially authorized, as at Alton and Saint Louis harbors, and on the easterly bank near Cairo.

Since the last report the Alton Dike has been completed to its full height of 14 feet above low water for a distance of 4,000 feet, the remaining portion, about 800 feet, being kept at a lower level. The good results previously reported have been maintained, and no further extension of this work appears to be required at present.

The revetment of the head of Arsenal Island has been finished, and the protection of the new banks formed by the system of works below has been continued. Additional hurdles have been put in at Horsetail, Twin Hollows, Pulltight, and Jim Smith's. Large deposits have been formed by these works, as expected, and the navigable channel defined by them has continued to improve, the least depths now reported being 12 feet at Arsenal Island, 9 feet at Horsetail, 8½ feet at Twin Hollows, and 10½ feet at Jim Smith's. The work at Cairo, for which $50,000 were specially appropriated, consisted in mattress protection of the slope below low water for a width of 120 feet and a length of about 3,500 feet, and in re-enforcing the upper bank revetment formerly built by the Cairo Land Company.

The works in this district suffered comparatively little injury during the winter and are now in good condition. The present value of the plant is estimated at about $198,000.

The expenditures during the time covered by the report were about $346,000, the balance available July 1 being about $113,000. For details see report of Major Ernst, Appendix F.

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WORKS BELOW CAIRO.

FIRST DISTRICT.

NEW MADRID AND PLUM POINT REACHES, 220 MILES.

Since the last report work in this district has been confined to the Plum Point Reach, and has been conducted in accordance with the general project described in the report of the Commission for 1883.

The works of contraction at Gold Dust, Plum Point, and Bullerton have been repaired and extended, and foot-mats have been sunk along the faces of the principal lines.

Mattress work and upper bank revetment were vigorously prosecuted to the close of the season at Fletcher's Field, Osceola Bar, Bullerton Towhead, and Craighead Point. The revetment work has remained in generally good condition, except at Craighead Point, where, although the foot mattresses appear to have kept in place, the upper bank revetment has disapppeared.

This last work was undertaken in an emergency to protect a caving bank, was prosecuted under great difficulties, and was suspended before completion when severe cold weather prevented the delivery of stone. The general effect of the contraction works in this reach has been good, the main channel from Plum Point giving 12 feet depth. The deposits within the areas inclosed by the dikes have continued, although there has been no rise of any considerable duration. Bullerton Chute is filling up rapidly and the average fill within the Plum Point lines is about 15 feet. The fill within the Gold Dust system has continued, being in many places considerably above low water. It is especially noted that the old channel cut off by the main dike near Cross-dike No. 1 has closed, changing from a depth of 33 feet at low water to a height of about 12 feet above low water, since October, 1884, a fill of about 45 feet, obtained mostly in one small flood.

Losses in this district have been confined chiefly to the earlier work, the dikes and revetments of later construction having suffered but little damage when completed and secured before floods set in. The present value of the plant used in this district is estimated at about $308,000. The expenditures during the time covered by the report were about $350,000, and the balance available July 1 is about $18,000. Special attention is invited to the remarks and suggestions in the report of Captain Leach, to which, with that of Assistant Notly, reference is made for details. (Appendices G and G 1.)

SECOND DISTRICT.

MEMPHIS REACH AND HARBOR, 180 MILES.

Work in this district was confined to the revetment of Hopefield Bend and of the caving bank of the Memphis City Front, Congress having specially provided $200,000 for the protection of Memphis Harbor. The work on the city front consists of wide continuous mattresses extending from low water to the foot of the slope, 250 to 300 feet, and substantial upper bank revetment, carried above high-water mark. The total length of revetment is about 4,700 feet, the submerged mattresses extending from the mouth of Wolf River about 1,600 feet down-stream.

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The entire work has withstood the effects of ice and this season's high water and appears to be secure. Work in Hopefield Bend consisted in the repair of breaks, the extension of the upper bank revetment for about 3,000 feet, and construction and sinking of about 3,000 feet of mattresses 150 feet wide. The work in Hopefield Bend has stood quite well. There have been several small breaks in the bank, due to slips, and about 2,000 feet of partial upper bank revetment, built in 1883, but not carried above high-water mark, have been lost. The continuity of the foot-mattress work appears to be unbroken.

The severe criticisms that have been indulged in concerning the Memphis and Hopefield Bend revetments do not seem to be justified by the facts.

The present value of the plant used in this district is estimated at about $97,000. The expenditures in this district during the time covered by the report, including $15,000 for levees, were about $228,000, and the balance available July 1 is about $1,500. Special attention is invited to the remarks of Captain Leach on the revetment of Memphis Front, to whose report and that of Assistant Rees, reference may be had for details. (Appendices H and H 1.)

THIRD DISTRICT.

LAKE PROVIDENCE REACH AND VICKSBURG AND GREENVILLE HARBORS, 220 MILES.

Before this improvement was undertaken the navigation of Lake Providence Reach was poor, the depth in low water being reduced frequently to 5 feet.

The general project consisted in preventing dispersion by closing the chutes and reducing the low-water width to about 3,000 feet by the construction of permeable dikes and the formation of artificial banks by deposit, and the preservation of the natural curves of the river by revetting caving banks. This reach has been improved so that there is now a navigable depth of 15 feet throughout its length. The greater portion of the work done in this district since October 1, 1884, has been the extension of the revetment in Louisiana Bend (Pilcher's Point), the repair of revetment at Mayersville, and the revetment of Delta Point, Louisiana.

No additional works of contraction were undertaken, operations having been limited to repairs of former work, the construction of three cross-dikes in chutes, and raising the screen work on main lines. The necessity for holding Louisiana Bend and Delta Point has been stated in former reports, but is briefly repeated again on account of their importance.

The caving of Louisiana Bend must be prevented in order to maintain the improvement of Lake Providence Reach, and Delta Point must be held both to maintain the regimen of the river for considerable distances above and below, and to prevent further recession of the river from Vicksburg.

The present value of the plant used in this district is estimated at $340,000. The expenditures (including levees) during the time covered by this report were about $447,000, and the balance available July 1 was about $26,000.

For details reference is made to the reports of Captain Sears and Assistant Hider, Appendices I and I 1.

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FOURTH DISTRICT.

HARBORS OF NATCHEZ AND VIDALIA AND NEW ORLEANS, MOUTH OF RED RIVER AND RECTIFICATION OF RED AND ATCHAFALAYA RIVERS, 484 MILES.

No work has been done on the harbors of Natchez and Vidalia since the date of the last report for want of funds.

The general plan recommended by the officer in charge in former reports contemplated protection of caving bends by means of submerged sloping spurs placed at intervals to be determined as work progressed, but assumed at 1,000 feet in preliminary estimate of cost, which was placed at $600,000.

A levee to prevent overflow of the neck between Giles' and Cowpen's bends was proposed at an additional cost of $100,000.

An estimate for mattress work and revetment instead of the method by spurs amounted to $1,040,000.

Work on the protection of that part of New Orleans Harbor known as Gouldsboro Bend by means of submerged spurs was suspended in November for want of funds. Two spurs were finished and one about half built. Nearly all the material, except brush, is on hand for completing the six spurs proposed for the protection of this bend. The slope of the spurs begins at low water, and will be varied as may be deemed advisable.

The effect of those now in place cannot be determined until low water.

The cost of the first spurs was about $12,500 each, but new work of this kind is expected to be considerably less.

The revised estimate of the officer in charge for the completion of work in New Orleans Harbor on this plan is $654,400.

Work in Red River has been limited to keeping the channel open to navigation between the Mississippi and the Atchafalaya by means of tug-propellors and scrapers. This was not successful, except at a point near the Atchafalaya, where a short bar existed with deep water above. Temporary spurs of willow brush were tried along one reach, and a scraper suspended from the bow of a stern-wheel boat was used at other places.

The present value of the plant used in this district is estimated at about $58,000.

The expenditures during the time covered by this report were about $177,000, the balance available July 1 being about $16,000. For details reference may be had to the reports of Major Stickney and Assistants Douglas, Wilson, and Price, Appendices K and K 1, 2, 3, 4, and 5.

LEVEES.

Second district.—No work was done on levees of the Yazoo Front. For the repair of Long Lake Levee, Saint Frances Front, $15,000 were allotted, provided the district officer should find repairs necessary for its safety, the levee from Helena to the end of Long Lake to be repaired and completed before November 1, 1884, to a grade 2 feet above the flood of 1882.

The conditions were complied with, and the work, amounting to about 60,000 cubic yards of embankment, was put under contract and finished in March, 1885. Work was commenced at the lower end, where there were a number of large gaps, the people living behind the upper portion being looked to for the repair of that part.

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Third district.—Work consisted in closing gaps in the levees on Yazoo and Tensas fronts, and comprised about 570,000 cubic yards of embankment. The work was put under contract in October, 1884, and all completed by April, 1885.

Fourth district.—Since the last report work has continued on Atchafalaya and Tensas fronts, chiefly the latter. About 9 miles of levees have been built or repaired, closing 40 gaps, and requiring over 300,000 cubic yards of embankment. The intervals remaining to be closed in this district aggregate about 32 miles.

The existing levees are now in fair condition, but are somewhat deficient in height.

For details reference may be made to the reports of the several district offices, Appendices H, I, and K.

PLAN AND METHODS OF IMPROVEMENT DISCUSSED.

The Mississippi River Commission, constituted under an act of Congress approved June 28, 1879, was required, in addition to completing the surveys then in progress and making such additional ones on the Mississippi River and tributaries as might be deemed necessary, to mature such plan or plans as will correct, permanently locate, and deepen the channel and protect the banks of the Mississippi River, improve and give safety and ease to the navigation thereof, prevent destructive floods, and promote and facilitate commerce and the postal service, and with such plans to prepare and submit estimates of the cost of executing the work.

It was also required under the law to report specifically upon the practicability, feasibility, and probable cost of the plans known as the jetty system, the levee system, and the outlet system; also to submit plans and estimates of cost of such immediate works as, in the judgment of the Commission, may constitute a part of the general system of works contemplated.

The first report of the Commission, dated February 17, 1880, discussed the jetty system, the levee system, and the outlet system, and recommended a plan of improvement which contemplates the concentration of the waters of the river as the principal agent in securing the needed improvement, and, briefly stated, the general and well-known principles on which the opinions of the Commission were based.

The outlet system, by which a portion of the flood waters of the river would be drawn off and conveyed through shorter routes to the Gulf, being one of diffusion and waste, and having very little in the way of either theory, experience or observation to recommend it, was unanimously rejected by the Commission for reasons set forth in the report.

The levee system and the degree to which levees might prudently be relied on as auxiliaries to a plan of improvement based on the concentration of the river waters was carefully considered. It was the opinion of a majority of the Commission that in time of bank overflow "levees exert a direct action in deepening the channel and enlarging the bed of the river"; that "they are regarded as a desirable though not a necessary adjunct in the general system of improvement submitted"; that "they are, upon a large portion of the river, essential to prevent destruction of life and property by overflow;" that "they give safety and ease to navigation, and promote and facilitate commerce and trade by establishing banks or landing places above the reach of floods, upon which produce can be placed while awaiting shipment, and where steam-

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boats and other river craft can land in times of high water"; that "the closure of crevasses will accomplish the removal of shoals caused by them"; and that "it is believed that the repair and maintenance of the extensive lines already existing will hasten the work of channel improvement through the increased scour and depth of river-bed which they would produce during the high-river stages." A rough estimate of the cost of closing the breaks in the then existing levees was submitted with the first report.

The plan of improvement recommended was discussed at some length in general terms, beginning with the general statement that "the bad navigation of the river is produced by the caving and erosion of its banks, and the excessive widths and the bars and shoals resulting directly therefrom." Further on the report said: "It would seem, therefore, that the plan of improvement must comprise as its essential features the contraction of the water-way of the river to a comparatively uniform width, and the protection of caving banks"; and, again, "wherever necessary, the new bank must be protected by a mattress revetment, or some equivalent device"; and, again, "as a general rule, the channel should be fixed and maintained in its present location."

In the Commission's third report, dated November 25, 1881, it was stated, without dissent or qualification from any member, that "the bank revetments are intended not only to stop the constant and in some localities very rapid enlargement produced by erosion and caving of bends, but in addition thereto to check the growth of bars and shoals below by accretions supplied directly therefrom."

The plan submitted by the Board of Engineers on the improvement of the low-water navigation of the river below Cairo, in their report of January 25, 1879 (House Ex. Doc. No. 41, Forty-fifth Congress, third session), in which they recommended "that the improvement be effected by narrowing the shoal and wide portions of the low-water river to about 3,500 feet, and by protecting caving banks where necessary," was unanimously adopted by the Commission for the initial works, and estimates and plans were given for "works of channel contraction and bank protection" on six reaches of bad navigation below Cairo, of an aggregate length of about 200 miles. In the report the cost of "works for contracting the channel" and "works for protecting the banks" was lumped together. The minutes of the proceedings of the Commission show, however, that a detailed estimate for each of the six reaches was prepared by a committee, presented to the Commission, and discussed and adopted without recorded dissent, all the members being present. In that estimate the works for bank protection on the six reaches were computed to cost four and half times as much as the works for channel contraction. On the Plum Point and Lake Providence reaches, the only portions of the river below Cairo on which works for the improvement of the channel have been undertaken, the works of bank revetment were estimated to cost nearly four and a half times as much as the contraction works.

The plan, therefore, contemplates the closing of outlets, both low-river outlets and crevasses; the contraction of the water-way of the river where the widths are excessive and the navigation bad; and the maintenance of the banks. In the execution of the plan thus briefly outlined, and in strict accordance with its original intent, and for no other object or purpose, the money appropriated by Congress has been expended.

The total cost of works of bank revetment and channel contraction

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actually executed by the Commission between Cairo and Vicksburg, from the time it assumed charge to June 30, 1885, has been as follows:

Works for "protecting the banks"	$2,240,000
Works for "contracting the channel"	2,500,000

This statement includes the first cost of plant, less its present value, and includes also the cost of its maintenance to June 30, 1885. It also includes the cost of all work done in the Plum Point and Lake Providence reaches; also the cost of the special work put in for the protection of Memphis and Vicksburg harbors, all of which was bank revetment. The works of bank protection, or bank revetment, have, therefore, cost a little *less* than the works for channel contraction, instead of about four and a half times as much which was the original and unanimous estimate of the Commission.

A very considerable portion of the sum expended for bank revetment was designed to give protection to certain sites and harbors —Memphis, Vicksburg, and others. These harbors were given in charge of the Commission at a later period, and some of them required special and prompt treatment. If Delta Point had not been held by revetting its banks with mattresses at considerable cost, the city of Vicksburg would long before now have been practically an inland town, entirely cut off from the river. At Memphis great values were also put in jeopardy by a rapidly caving bank, which threatened to carry off a portion of the city. Bank revetment, as offering the only possible means of arresting the danger, was successfully applied in this case, although a portion of the work first put down was carried away, the loss of work put in by the Commission on both sides of the river amounting to 17⅔ per cent. of its cost.

It has been claimed that the caving of banks should be arrested by works of channel contraction at the wide places above, and much unwarranted stress seems to have been laid upon a hypothetical discussion introduced into the first report of the Commission, where it is stated theoretically that "uniform depth joined to uniform width—that is to say, uniformity of effective cross section—implies uniform velocity, and this means that there will be no violent eddies or cross-currents, and no great and sudden fluctuations in the silt-transporting power of the current." But it is nowhere asserted in that report, nor is it believed by the Commission, that uniform depth, or any very near approach to it, is practically attainable upon the Mississippi River, or upon any large silt-bearing stream flowing through an alluvial bed and having a difference of 45 to 50 feet between its high and low water stages. In its low stage the obstructed portions of the river present a series of shallow crossings or bars, where the width is excessive and upon which there is frequently only about 6 to 10 feet depth of water, alternating with concave bends, where there are depths of 80 feet, and in some places of 90 to 95 feet and upwards. The scour induced by works of improvement at the wide places will doubtless deepen the channel across the bars to 15 or 20 feet, leaving the depths in the bends substantially unchanged, so that the full measure of approach to uniform depth attained by these results consists in this, that where there formerly existed, as between the deep bends and the shallow bars, a difference ranging from 70 to 90 feet in depth, there now exists, after the improvement, a difference of 60 to 80 feet or more. This represents an amelioration of former conditions, which, although sufficient for purposes of navigation, is evidently too small to affect in any considerable degree, or perhaps in any sensible degree, the cross-currents, eddies,

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and fluctuations of velocity resulting from constantly varying depths. It would seem, therefore, that stability of banks, as the result of such uniformity of depth as can be secured by works of contraction, is practically unattainable. For this reason the plan of improvement contemplated a liberal use of bank revetment, roughly estimated to cost more than four times as much as the corresponding works of channel contraction.

It may be stated that it is not the intention nor has it been the practice of the Commission to protect a bank by revetment merely because it is caving. Other considerations must govern this question. But where an imminent danger threatens the immediate destruction of interests of great value—as, for example, where a caving bend is about to take in flank and carry away costly works of improvement or produce a disastrous cut-off, or where a city's river front is to be maintained, as at Vicksburg, or a portion of the city itself to be protected against undermining, as at Memphis—then it is believed to be imperative that the local remedy of holding the banks intact by a mattress revetment or other equivalent device should be adopted.

For a somewhat extended discussion of the phenomena of velocity, sediment transportation, and bank erosion, and the mutual relations among them, with pertinent tables and other data, reference is made to a paper by Commissioner B. M. Harrod, hereto annexed as Appendix B.

The money percentage of damage and loss in works constructed under the direction of the Commission from the time of its organization to June 30, 1885, between Cairo and New Orleans, is about as follows, the figures being above rather than below the exact percentage:

	Per cent. of cost.
Damage to works of channel contraction	22
Damage to works of bank protection	26
Aggregate damage to both classes of work	24

The foregoing includes the cost of maintenance of plant, and also its original cost less its present value. The varying methods of doing work, the frequent interchange of labor and materials between different points, and the difficulty of maintaining a well-arranged system of recording losses have rendered great precision unattainable. As a matter of precaution, outside figures are given.

It is in view of serious misapprehensions touching the original plan and recommendations of the Commission which have come to its notice, that it has been thought proper to make this somewhat extended reference to the place which the work of bank protection had in that plan, and to the amount, cost, and efficiency of the work of that kind which has been done.

THE ATCHAFALAYA OUTLET.

The apprehension which has prevailed to some extent that the Mississippi River may at any time, and probably will at an early day if left to itself, suddenly break through into the Atchafalaya, and thereafter make that stream its principal route to the Gulf, has never been shared by the Commission in the sense that the danger is imminent and not subject to easy control. There has been no enlargement of Lower Old River between the Mississippi and the head of the Atchafalaya, and no apparent tendency to enlargement. On the contrary, more or less dredging has been necessary every year to keep the passage open for the class of steamers navigating those waters, and even dredging failed to maintain the channel during the low-water stage of 1883, and all

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steamboating on that route was suspended for several weeks. At the close of the fiscal year ending June 30, 1885, considerable shoaling was reported by the engineer officer in charge. The Commission has not failed, however, to recognize the fact that there is danger that in the event of a prolonged concurrence of high water in the Mississippi and low water in the Red, the existing outlet might be gradually enlarged to a capacity sufficient to discharge a large portion of the main stream, thus adding to the cost of any plan of works or method of treatment that might finally be adopted for that locality, whether designed to close it as an outlet or to convert it into a tributary.

In its last report, dated December 19, 1884, the Commission submitted a "plan for the rectification of the Red and Atchafalaya rivers by preventing further enlargement of the latter stream and restricting its outlet capacity." The plan comprised a series of six low dams in the Atchafalaya, to be subsequently connected with high levees across the head of the Atchafalaya Basin. A low-water dam to be placed in Lower Old River, between the Atchafalaya and the head of Turnbull's Island, was also suggested, having its crest 10 feet higher than the obstructions in Upper Old River, in order to deflect the Red, when below that level through the last-named channel.

The present recommendation is restricted to the low dams in the Atchafalaya, which, in the judgment of the Commission, should be begun by laying at least the sill-courses for all of them as soon as the stage of water will permit after funds shall have been provided for that purpose. Any modification of the details of the plan which may seem to be desirable will of course be made. The rapidity with which the dams shall be raised to greater height will be made the subject of careful study. All questions connected with the adjacent high-grade levees on either side, and with the low-water dam in Lower Old River above the Atchafalaya, will be held in abeyance for the present and made the subject of further recommendations.

VICKSBURG HARBOR.

It is desirable that a moderate portion of the first appropriation that shall become applicable to that purpose shall be expended upon the initial works of a plan having for its object the gradual restoration of the harbor of Vicksburg to or in the direction of its former condition, in such measure at least as shall give a portion of the city a water front at the low-river stage. This will be attempted by such works of contraction and deflection, located at suitable points above as shall ultimately effect a diversion of the main body of the stream to the Vicksburg side and a recession of the shore-line above the city, by the usual process of erosion and caving. An early effect will be to relieve the pressure, and therefore put a stop to expenditures at Delta Point. If the restoration of a navigable low river front to a portion of the city of Vicksburg, at a reasonable cost, is practicable, it will require several years for its final consummation in the manner proposed.

LEGISLATION.

The Commission renew the recommendation heretofore made that provision be made by law for the appropriation by the United States, through proceedings in the Federal court, of land and material needed in the work.

On this point reference is made to the suggestions of the report for 1883, without repeating them here.

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The attention of Congress is further invited to the losses to assistant engineers mentioned in the secretary's report, Appendix C, of personal property, such as clothing, books, &c., incurred by the sinking of a survey-boat while being towed from one locality to another. These losses falling upon persons dependent upon their salaries are of much importance to them, and being incident to the service upon which they were engaged, and entirely beyond their control, reimbursement would be just and proper.

FINANCIAL STATEMENT.

Appropriation for salaries and expenses Mississippi River Commission, act of July 7, 1884.

Appropriated by act of July 7, 1884	$75,000 00
Balance on hand December 1, 1884	59,355 74
Expended from December 1, 1884, to June 30, 1885	36,634 50
Balance on hand July 1, 1885	22,721 24

Appropriation for surveys of Mississippi River, act of July 5, 1884.

Amount appropriated	$75,000 00
Balance on hand December 1, 1884	49,463 28
Expended from December 1, 1884, to June 30, 1885	33,314 71
Balance on hand July 1, 1885	16,148 57

Appropriation for Improving Mississippi River, acts March 3, 1881, August 2, 1882, and January 19 and July 5, 1884.

Total available October 1, 1884, for Improving Mississippi River		$2,031,753 91
Reverted to Treasury	$123 42	
Transferred to snag-boat service	5,000 00	
		5,123 42
Balance		2,026,630 49
Received from sale of fuel		179 57
Total		2,026,810 06
Expended		1,636,832 01
Balance available July 1, 1885, to meet liabilities and to carry on work under the Mississippi River Commission		389,978 05

The estimates of funds for fiscal year 1886, which were transmitted to the honorable the Secretary of War on July 25, 1884, are here repeated:

ESTIMATE OF FUNDS FOR THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

River and harbor bill.

For continuation of surveys of the Mississippi River between the Head of the Passes, near its mouth, and its headwaters, now in progress; to make additional surveys and examinations of said river and its tributaries; to make such additional examinations and investigations, topographical, hydrographical, hydrometrical, as are necessary for maturing a plan for the permanent improvement of the entire river	$100,000

Sundry civil bill.

For salaries and traveling expenses of the Mississippi River Commission, and for salaries and traveling expenses of assistant engineers under them, and for office expenses and contingencies	100,000

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The following estimate of funds for works of improvement for the fiscal year ending June 30, 1887, are submitted:

ESTIMATES OF FUNDS FOR THE IMPROVEMENT OF THE MISSISSIPPI RIVER FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

For continuing the improvement of the Mississippi River from Des Moines Rapids to the mouth of the Illinois River	$500,000
For continuing the improvement of the Mississippi River from the mouth of the Illinois River to Cairo, Ill	1,000,000
For continuing the improvement of the Mississippi River from Cairo, Ill., to the Head of the Passes, including the improvement of the Red River at and below the head of the Atchafalaya	5,000,000

The names of a large number of harbors were inserted in the river and harbor bill, with a view to their improvement; but as the amount appropriated was far short of the estimates of the Commission, they did not feel justified in taking up this work except at Memphis, where the act specified the amount to be expended, and at Vicksburg, where repairs were needed to work already done. The Commission have, however, prepared the following separate estimates for such work at these places as seems necessary to accomplish the objects proposed, and these estimates are submitted to Congress for such action as they may deem proper, it being the desire of the Commission, if Congress decides that any or all of this work be undertaken, that they will specify the localities and the amount to be expended at each.

For improvement of the following harbors:

Columbus, Ky	$80,000
Hickman, Ky	270,000
Memphis, Tenn	75,000
Greenville, Miss	186,000
Vicksburg, Miss	20,000
Natchez, Miss	700,000
New Orleans, La	683,600
Total	2,014,600

Q. A. GILLMORE,
Colonel Engineers, Bvt. Maj. Gen., U. S. A.,
President Mississippi River Commission.
CHAS. R. SUTER,
Major of Engineers, U. S. A.
HENRY MITCHELL,
Coast and Geodetic Survey.
B. M. HARROD.
R. S. TAYLOR.
S. W. FERGUSON.

To the Hon. the SECRETARY OF WAR.
(Through the Chief of Engineers.)

While I generally concur in what is said in the foregoing report, I wish to add a few words by way of enlargement.

The cost of improving the Mississippi River in the manner and to the extent contemplated will doubtless considerably exceed the estimate formerly submitted by the Commission. For this there are two reasons principally: First, that it has been found necessary to make use of stronger and firmer, and therefore more expensive, methods of construction than those upon which, from a want of experimental knowledge, that estimate of cost was based; and, second, that the percentage of loss from floods has exceeded what was formerly thought to

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be a fair allowance for this contingency. Much of this loss, however, would have been spared had the stronger methods of construction been resorted to at an earlier day, and future loss from this cause may therefore in some measure be avoided. In other respects, also, the experience gained in the application of new and untried devices cannot fail to tend in the direction of economy.

There seems to be no just ground for apprehension that the ultimate cost of this improvement will be inordinately great, or will exceed what the Government will be fully justified in expending upon a great national work, in the success of which so large and so varied interests are involved. In order, however, that the increased depths already secured upon two reaches of bad navigation may be utilized or made of some practical value, the improvement should be extended up-stream and down. Indeed, it cannot be said that the navigation has received any practical benefit whatever so long as the improvements are restricted to localities hemmed in by bad river above and below. It might be better, were no middle course left open, to spread each appropriation judiciously over all the six reaches of bad navigation selected for improvement below Cairo, adding a little each year, if practicable, to the available depths on the worst bars, than to confine the work to the Plum Point and Lake Providence reaches, as heretofore, even if the low river navigation of these two localities should be rapidly deepened to 20 feet, and the feasibility of the Commission's plan thereby fully demonstrated. The objective point is the improvement of the river, and not the vindication of the agents employed on the work, except as means to an end.

With regard to the estimates submitted, the Commission does not recommend that the sum of $2,014,600 should be appropriated for the seven harbors named, viz, Columbus, Hickman, Memphis, Greenville, Vicksburg, Natchez, and New Orleans. That sum is named as the aggregate cost of works of protection at those localities, as set forth in the last annual report of the Commission, bearing date December 19, 1884. In that list the sum of $20,000 set down for Vicksburg was intended exclusively for the maintenance of the Delta Point revetment.

In the report now submitted a special method of treatment for Vicksburg Harbor is described, and I recommend that the sum of $50,000 be set apart by Congress for beginning this work.

With regard to the conditions existing at the Red and Atchafalaya rivers, the work to be done there will, or should, have for its object the gradual contraction, and perhaps, finally, the complete closure, of the latter as an outlet of the Mississippi. Whether the treatment should be carried further than this, to the extent of making the Red River a tributary of the Mississippi, by the construction of a high dam across the head of the Atchafalaya River and basins, thus cutting off the latter stream from the navigation of the Red and Mississippi rivers, is a question involving considerations of very great moment. Fortunately its determination at the present time is not imperative, as the works necessary for its accomplishment naturally follow in order of time, those which may be built for simply contracting the outlet or preventing its enlargement.

By the principles enunciated as the basis of its plan of improvement the Commission is distinctly committed to the idea of closing all outlets as part of that plan, both low-river outlets and breaks in the levees, and it has consistently opposed the fallacy known as the "outlet system," because it stands in sharp antagonism to those principles and to all the fundamental laws of hydraulics. When the Atchafalaya shall cease to be

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an outlet, the discharge of the Mississippi below the mouth of Red River will be increased about 40 to 50 per cent. by the addition of the volume now abstracted by the outlet. How long a time must necessarily elapse before the river, by a gradual enlargement of its bed, will be able to retain within the existing levees and safely carry off this increased volume, is largely a matter of conjecture. That it would do so in time will doubtless be very generally conceded by engineers who are familiar with the character of the deposits which have to be scoured away. Mr. Eads estimates that six years should be allowed for completely closing the head of the Atchafalaya Basin by such high works as will divert all the Red River flow into the Mississippi. While I am not prepared to say that this interval of time would not suffice, it would certainly be prudent to make it longer; for there might be an uninterrupted succession of moderate floods for four or five years, which would not overflow the banks even with the increasing additions due to the closure works in progress. If there should then occur a large flood when the works were nearly finished, the bed of the river would not be in condition to carry it off, and very disastrous consequences might ensue, more especially if both the Mississippi and the Red were in flood at the same time. But whatever interval of time may be allowed for the construction of the closing works, and the gradual enlargement of the river-bed, the levees below Red River should be carefully maintained during that time to their full height, strengthened wherever weak, and all breaks occurring therein promptly closed. As there are no portions of the river where levees sustain relations to the general plan of improvement more important than those which obtain in these lower reaches, so there are none where their importance is more likely to be underestimated or even entirely overlooked, for the reason that, the lower-river channel being at all times sufficiently deep for purposes of navigation, levees do not suggest themselves at all as a means of improvement below Red River. The essence of the whole matter is apt to be lost sight of, that they are required below for the benefit of the river above, and that they are valuable in proportion as they help to enlarge the river bed, facilitate the discharge of the floods, lower the flood heights, lessen the difference between high and low river, and thereby ameliorate and simplify all the difficulties of improvement. Indeed, were it necessary to omit the maintenance of levees, as an auxiliary means, on any portion of the stream, they might better be omitted above than below Red River. Were it possible to enlarge the bed of the river to a capacity that would be sufficient to carry off the flood-waters without any rise above the tide-level as far up as Red River, which would be practically extending the Gulf more than 300 miles up-stream, there would then be no greater difference between high and low river at that point than that due to the tidal oscillations, while for fully 200 miles higher up the largest floods would doubtless be retained within the natural bed. Works of improvement below Red River, of whatever character, are valuable as such only so far as they tend to the development of these conditions—that is, only so far as they aid in securing an enlarged local water-way. The general benefits to which reference has been made will be certain to follow in due proportion.

Respectfully submitted.

Q. A. GILLMORE,
Colonel Engineers, Brevet Maj. Gen., U. S. A.,
President Mississippi River Commission.

The Hon. the SECRETARY OF WAR.

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(1) I fully concur in the opinion that any attempt to improve the navigation of the Lower Mississippi by contraction works alone, without the extensive use of bank protection, would be a failure. I think, even if it were possible in that way temporarily to improve the river, it would be only temporarily, since the river, still free to cave in its bends, would recede from those works unless the bends were held by protection-works, and would thus return to its present bad condition.

Not believing that contraction works alone can improve the navigable depth of the river, neither do I believe that revetment works alone can do it, and I am not in favor of either class of works, except in proper connection with the other. The Mississippi is like other rivers, differing only in size, and the general plans for improving rivers in alluvial bottoms, followed for many years in Europe and tested by experience, must be followed here—namely, contraction works, to secure increased depths where needed, and protection works in caving bends, to prevent the river from abandoning or destroying the contraction works, either during their construction or after their completion.

(2) I have little hope that the Mississippi can be forced at any justifiable cost far enough up along the Vicksburg front, which it has abandoned, to be of much use to that city. As there will be no funds available for about a year, the decision as to action should be based on conditions then existing.

(3) The Commission submits an estimate for an appropriation of $5,000,000 below Cairo. I am not prepared to recommend to Congress the beginning of work on any new reaches below Cairo until the final cost of the plan of the Commission for the improvement of the Plum Point and Lake Providence reaches is approximately known. At present no reliable estimate can be made, but the cost is already great. The final cost may be so great as to render a general improvement of the river inadvisable. Until this question is settled, work should not be begun on a great scale.

A million of dollars for the Plum Point Reach, as much for the Lake Providence Reach, half a million for the Memphis Reach and the sills in the Atchafalaya, is ample for the prosecution of these works in the coming fiscal year.

C. B. COMSTOCK,
Lieut. Col. of Engineers, Bvt. Brig. Gen.

NEW YORK, *July* 3, 1885.

HON. WM. C. ENDICOTT,
Secretary of War.
(Through the Chief of Engineers, U. S. A.)

STATEMENT OF APPROPRIATIONS ALLOTTED AND EXPENDED FOR WORKS OF IMPROVEMENT UNDER THE MISSISSIPPI RIVER COMMISSION.

Act of March 3, 1881	$1,000,000 00
Act of August 2, 1882	4,123,000 00
Act of January 19, 1884	1,000,000 00
Act of July 5, 1884, less $5,000 transferred to snag-boat service	2,065,000 00
Total	$8,188,000 00
Balances from former appropriations for works below Cairo, July 1, 1882, less $123.42 reverted to the Treasury	272,504 96

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Balances from former appropriations for works above Cairo, July 1, 1884	$22,632,53
For sale of fuel and loss of property	411 07
Total	$8,483,548 56

Expended to June 30, 1885:	
Des Moines Rapids to Illinois River	$120,949 22
Illinois River to Ohio River	389,339 56
Protection of easterly bank of Mississippi River near Cairo	27,839 99
New Madrid Reach	210,364 74
Plum Point Reach	2,379,019 12
Memphis Reach	477,073 04
Memphis Harbor	198,580 97
Lake Providence Reach	2,240,285 73
Vicksburg Harbor, dredging	61,812 12
Vicksburg Harbor, Delta Point	115,573 71
Survey of Helena Reach	8,000 00
Survey of Saint Francis Front, first district	4,873 11
Survey of Saint Francis Front, second district	4,000 00
Survey of unleveed fronts, third district	1,000 00
Survey of unleveed fronts, fourth district	1,000 00
Survey of Cubitt's Gap	137 14
Survey of Choctaw Bend	2,679 86
Observations at Carrollton	3,000 00
Closing Bonnet Carré crevasse	15,000 00
Levees.	
Second district:	
Yazoo Front	$80,950 00
Long Lake	15,000 00
Third district:	
Opossum Fork	25,000 00
Yazoo Front	364,875 45
Tensas Front	411,107 74
Fourth district:	
Atchafalaya Front	133,503 93
Tensas Front	548,258 24
Mouth of Red River	98,386 32
Natchez and Vidalia harbors	6,626 09
New Orleans Harbor	149,334 43
Total	$8,093,570 51
Balance July 1, 1885	$389,978 05

Respectfully submitted.

J. H. WILLARD,
Captain of Engineers,
Secretary Committee on Construction, Mississippi River Commission.

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APPENDICES.

APPENDIX A.

PAPER BY GENERAL COMSTOCK ON EFFECT OF OVERFLOW IN DIMINISHING VELOCITY OF MISSISSIPPI RIVER, AND ON EFFECT OF LEVEES ALONG YAZOO FRONT ON FLOOD HEIGHTS IN 1883.

To the Mississippi River Commission:

In the part of the last Annual Report of the Mississippi River Commission relating to levees and outlets certain views were expressed as to the effect of escape of Mississippi River water over the river-banks in diminishing the velocity of the main river, and on the effect of levees on the flood height in 1883 at Vicksburg, in which I did not concur.

There was then no time to discuss them, as it was necessary to forward the report at once. I have since examined these questions, and now state my reasons for disagreement with those views.

(1) First as to the theory that when escape over the Mississippi River banks begins, velocities in the main river are checked and deposits induced, and that the checking of velocity arises from this escape.

At some of the gauging stations of the Commission, when the river rises from about overflow stage to its maximum height, the velocities cease to increase with increased stage, and that part of the velocity curve becomes vertical.

The theory above mentioned has been advanced as an explanation of this peculiarity in the velocities.

The velocity curves should then be examined, to see if they support this theory.

The following lists give the names of places where we have a series of measures of the river's velocity both above and below the stage at which overflow begins. The number above the name gives the highest observed gauge-reading in the discharge observations, and the number under the name gives the stage at which overflow begins:

An examination of the velocity curves shows that at $\underset{192.9}{\text{Prescott}}$ below the Saint Croix, $\underset{446.79}{\underset{443.4}{\text{Winona}}}$, $\underset{50.17}{\underset{49.7}{\text{Saint Louis}}}$, $\underset{34.17}{\underset{32.0}{\text{Fulton}}}$, $\underset{49.77}{\underset{41.0}{\text{Paducah}}}$, $\underset{102.79}{\underset{95.0}{\text{Columbus}}}$, $\underset{188.1}{\underset{47.1}{\text{Helena}}}$, $\underset{48.5}{\underset{44.5}{\text{Red River Landing}}}$, the velocities increase steadily to the highest gauge-reading without any important break in the regularity of the form of the curve.

In the curves for $\underset{34.42}{\underset{29.2}{\text{Grafton}}}$ and $\underset{88.20}{\underset{82.0}{\text{Hannibal}}}$ there are indications of a change in the form of the curve, without its being very pronounced.

At Grafton the velocities are complicated by the nearness of the Illinois and Missouri rivers.

As the river rose from 32.2 feet on April 25, 1881, to 34.2 feet on May 5, the mean velocity fell from 4.6 feet to 3.9 feet. But water passing Leavenworth would reach the mouth of the Missouri River about five days later. Between April 20 and April 30 the Leavenworth gauge rose from 17.5 feet to 26.75 feet. When this rise reached the Missouri mouth, April 25, it produced a local rise there, backed the water up the Mississippi, and, diminishing the slopes, diminished the velocities at Grafton.

This Missouri rise showed itself at Saint Louis by a rise between April 25 and May 6 of 4.8 feet, the Grafton rise being but 2.0 feet.

At Hannibal there are no data for examining the question of slope.

At $\underset{17.98}{\underset{11.0}{\text{Clayton}}}$ and $\underset{38.59}{\underset{34.4}{\text{Hays' Landing}}}$ the change in the form of the curve is unmistakable.

(2) At Clayton the data are not very precise, but Lieutenant Leach reports (January 16, 1884) that existing information indicates that at the top of the flood the slope between Prairie du Chien and Clayton was about 20 per cent. less than at the gauge-readings when the curve changes its direction.

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This decrease in slope would nearly balance the effect of increase from 14 feet to 18 feet in gauge-reading in increasing the velocity, and should make the velocity constant between the gauge-reading, as it is.

The fact that the slope of the main river is reduced, probably by a damming effect below, is enough to account for the change in form of velocity curve, without invoking the theory that escape over banks of itself at once reduces at the place of escape the velocity of the whole main river below its value before escape began.

In estimating the effect of change of slope on velocity for small changes in gauge-readings, the formula $V=C\sqrt{rs}$ is used, as it is known to give good results. V is the mean velocity, r the hydraulic mean radius, and s the fall in unit length.

(3) The second very marked change in the form of the velocity curve is at Hays' Landing.

From January 21, 1882, to March 20, 1882, the Hays' Landing gauge increased from 34.3 feet to its maximum, 38.6 feet. During this rise of 4.3 feet, the velocity curve was nearly vertical, or, rather, was inclined somewhat backward. On April 18 the gauge had fallen to 34.6 feet, and in this fall of 4.0 feet the velocity curve was also nearly vertical.

Again, on March 20, the gauge being 38.6 feet, the mean velocity was 5.4, while on June 6, the gauge being 34.1 feet, or 4.5 feet lower, the mean velocity was 6.3 feet, or 0.9 foot greater.

Were these peculiarities due to escape of water over bank and to the cessation of that escape?

The following table gives the data referred to, and also the fall on the same dates of the water surface between Lake Providence and Vicksburg:

Date.	Hays' Landing gauge.	Mean velocity.	Mean depth.	Fall, Lake Providence—Vicksburg.
	Feet.	*Feet.*	*Feet.*	*Feet.*
January 21, 1882	34.3	6.1	59.6	17.6
March 20, 1882	38.6	5.4	61.0	13.1
April 18, 1882*	34.6	5.3	60.8	14.0
June 6, 1882	34.1	6.3	62.1	17.2

*April 18, 19, 20, 21, the Hays' Landing gauge varied little, the mean of mean velocities on these days was 5.6 feet.

From this table it is seen that the mean depths varied but slightly, so that the cause of the changes in the mean velocities must be sought almost entirely in the changes of slope. From January 21 to March 20, while the river rose, the average slope from Lake Providence to Vicksburg diminished by 25 per cent. This should cause a diminution in mean velocity of 13 per cent. The actual diminution was 11 per cent. On March 20 and April 18 the mean depth was practically the same, although the river had fallen 4 feet. The slope increased 7 per cent., which should increase the velocity by 3 per cent. The velocity actually decreased by 2 per cent., but these quantities are so small that they are without certainty. The river fell 4 feet, but it also scoured 3.8 feet, so that the mean depth remained practically the same, as did the velocity. From March 20 to June 6, 1882, the mean depth increased by 2 per cent. and the slope by 23 per cent. These should give an increase of velocity of 12 per cent. The actual increase was 16 per cent.

It seems then that these chief irregularities in the Hays' Landing velocity (and hence discharge) curve are accounted for, as closely as could be expected, by the changes in slope in the main river, and hence, that there is no need to call in aid the theory that escape of water over the river banks makes the velocity less than before the escape began, and thus induces deposits.

(4) The cause of the great loss of slope between Lake Providence and Vicksburg, beginning prior to March 20, and nearly ending prior to June 6, is seen at once on examining the gauge curves. The great return flow from the Yazoo Swamp began to be of importance at Vicksburg about March 4, and was nearly over by May 19. During this time it was a great tributary, raising the river at Vicksburg several feet above the stage due to the water coming down the main river, and backing up the river as far as Lake Providence, thus diminishing the slope and the velocity.

(5) Finally, of the twelve stations considered, while at all the river went over its banks, but four show a stop in increase of velocity when the overflow stage is reached. Of these four the peculiarity at three is accounted for by the known slopes in the main river, and in the case of the fourth the data are not sufficient for discussion. If they were, the peculiarities would probably be accounted for in the same way.

It seems then that the cases considered give practically no support to the theory under consideration.

Whenever, as at Helena and Vicksburg, enormous quantities of water are added by

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return flow to that flowing in the main river, there will be a local rise above the stage due to the main river alone. The effect of this local rise will be to diminish slopes and velocities for long distances above, the effect in the case of Vicksburg reaching to Lake Providence. This diminution in velocity does not occur when the escape begins, nor in consequence of the escape, but long after, when the return flow begins, and in consequence of that return flow. The return flow acts precisely like a tributary.

(6) The question whether, when escape over banks begins, the velocity in the main river is thereby reduced below what it was before escape began, may be examined in another way. The formula for mean velocity $V=C\sqrt{rs}$, shows us that in general terms the mean velocity can be reduced by diminution in mean depth, or in slope. But as the theory supposes rise in the river bed, to result from loss of velocity, the loss of velocity must precede diminution in depth, and hence can only arise from preceding diminution of slope. Even if, for instance, between Memphis and Arkansas City there were to be a mean rise in the river bed of 5 feet, as the mean depth of the river at flood is something like 50 feet, this diminution in r, in the formula, would only diminish the mean velocity by 5 per cent., a quantity that is less than the possible error in a good gauging.

Hence, immediately after escape begins, if there is any marked diminution in the velocity of the main river, it must inevitably be accompanied by a marked diminution in the slope of that part of the river where the escape takes place; if no such diminution in slope occurs, it is certain that no marked diminution in velocity in the main river will occur.

In the flood of 1882, the measured escape into the Yazoo bottom, between Memphis and Arkansas City, was 780,000 cubic feet. If there is any truth in the theory under consideration, this enormous escape should show itself in a large diminution in the velocities and in the average slope of the river between the two places, in the interval of time between the beginning of the escape and the date on which it reached its maximum amount. Escape began at Memphis on January 15, 1882, with Memphis gauge reading 29.5 feet. On February 28, 1882, the gauge at Arkansas City reached its maximum.

The following table gives the falls in the river surface between gauges on these dates:

Locality.	Fall on January 15, 1882.	Fall on February 28, 1882.
	Feet.	*Feet.*
Memphis to Helena	31.8	30.9
Helena to White River	31.6	30.5
White River to Arkansas City	13.8	13.8
Total fall	77.2	75.2

That is, the diminution in slope between these dates does not amount to 4 per cent either for the whole or the partial distances. This diminution in slope would correspond to a diminution of mean velocity of less than 2 per cent., a quantity so small that accurate discharge-observations would probably fail to detect it. Moreover, between these dates, the return flow from the Saint Francis Swamp had begun, and had locally raised the river at Helena and below; without this disturbing element it is probable that the slope between Memphis and Helena would have increased instead of having slightly diminished.

It seems, then, that this method of examination also negatives the supposition of a sudden diminution in the velocity of the main river when overflow begins.

(7) *Did levees, built in* 1882–'83, *reduce flood heights at Vicksburg in* 1883?

In 1882 and 1883 the floods at Helena reached nearly the same heights, namely, 47.2 and 46.9 feet, while these floods at Vicksburg reached heights of 48.7 and 43.8 feet, or the second was about 5 feet lower. This reduction in flood-height at Vicksburg has been attributed to levees built in 1882–'83.

It does not seem necessary to go to the levees as a cause for a result which would have occurred without any change in them. The maximum flood at Vicksburg, in both years, was caused by the superposition of the Yazoo Swamp outflow on the water flowing in the river. In 1882 J. B. Johnson observed an escape into the Yazoo bottom of 780,000 cubic feet per second, and H. Stewart observed that of 1883 as 546,000 cubic feet per second.

The maximum return flow in any second was probably less at Vicksburg in 1883 than in 1882, but the return flows in the two years affected the Vicksburg gauge by about equal amounts.

Were these return flows superposed in the two years on equal discharges of the main river? Or was the discharge of the main river above the entrance of the Yazoo Swamp discharge very much less in 1883?

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Helena is 293 miles above Vicksburg, and the water which follows the river passes in flood over this distance in about three days. If then, the Helena gauge be examined three days before a given date at Vicksburg, an idea can be formed as to the amount of water which, coming from Helena, is passing Vicksburg on that date.

In 1882 the maximum stage of 48.7 feet was reached at Vicksburg on March 20. The river stage at Helena three days before was 46.2 feet, and it was this 46.2 feet discharge plus that of Arkansas and White rivers plus the Yazoo Swamp return flow* which carried the Vicksburg gauge to 48.7 in 1882, on March 20. In 1883 the Vicksburg gauge reached its maximum, 43.8, on April 7. Three days before the Helena gauge read, on April 4, 1883, 32.7 feet, in place of 46.2 in 1882. It was this 32.7 feet discharge plus the Arkansas and White rivers plus the Yazoo Swamp discharge which gave the Vicksburg maximum of 43.8 in 1883, on April 7. 46.2 minus 32.7 is equal to 13.5 feet, and this difference in the Helena gauge in the two years ought to largely reduce the Vicksburg gauge in 1883. It and the probably smaller return flood reduced it 4.9 feet below 1882.

But while the Mississippi at Helena was carrying much less water in 1883 than in 1882, three days before the Vicksburg maximum, the Arkansas and White rivers were also adding less water to the Helena discharge. Allowing seven days for the water at Little Rock and at Jacksonport to reach Vicksburg, it may be said that in 1883, seven days before the Vicksburg maximum, the Little Rock and Jacksonport gauges read 10 feet and 9 feet, while in 1882 they read 16 feet and 22 feet.

In view of the far less flow past Helena at the time of the Vicksburg maximum in 1883 than in 1882, the Helena stages being 32.7 and 46.2, respectively, and in view of the smaller contribution of the White and Arkansas rivers, the theory that levees reduced flood height at Vicksburg in 1883 as compared with 1882 is not needed to account for the facts.

C. B. COMSTOCK,
Lieut. Col. of Engineers,
Bvt. Brig. Gen., U. S. A.,
President Mississippi River Commission.

NEW YORK, *March* 15, 1884.

APPENDIX B.

PAPER BY COMMISSIONER B. M. HARROD, ON THE PROTECTION OF BANKS.

I desire to submit the following observations and opinions concerning the protection of banks as part of the plan of improvement of the river below the mouth of the Missouri.

Whenever the movement of current against a bank has sufficient force, either from mass, velocity, or angle of impact, the submerged part is scoured away and the superincumbent bank "caves." Therefore, this action largely occurs in deep and narrow bends, where the resistance of the banks must impress a curved motion on the flowing mass; in wide reaches at the lower ends of crossings; or at any other place where the location or direction of the channel subjects the bank to abnormal stress.

In this practical way is the caving of banks accounted for rather than by the theory that the charge of sediment always has or is seeking a fixed relation to the velocity, coupled with the dogma that the erosion of banks results from an undercharge of sediment in the passing water, and not from the friction or impingement of the current against them. From the theory here alluded to is drawn the conclusion that the uniformity of velocity caused by uniform section will so adjust the load of sediment that it cannot be increased, and therefore that the banks will not erode.

Of course the movement of water and the suspension of sediment stand as cause and effect and their relation is governed by law, but our knowledge thereof as concerning the Mississippi below the Missouri is still quite covered by the expressions used by the majority in the first report of the Commission:

"No fixed relation has been discovered between a volume of water and the sediment in it for any given observed velocity. The supply of earthy matter is very irregular, varying greatly, irrespective of changes of velocity, with fluctuations in the stage of river, the relative discharge of different tributaries, the seasons of the year, the conditions governing rainfalls, alternations of freezing and thawing, the kinds of crops cultivated in the vicinity, and other causes."

The observations conducted by the Commission have corroborated fully the authority on which this statement is made.

I here insert tabulated results of an examination of every extended series of sediment observations made between Cairo and the head of the passes. These are five in number, as follows: Carrollton, 1851-'52, Humphreys and Abbot; Columbus, 1858,

*Strictly this should be excess of return flow over escape below Helena. A number of corrections have been made in the original paper.—C. B. C., July, 1885.

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Humphreys and Abbot; Columbus, 1879, Maj. C. R. Suter; Fulton, 1879–'80, Mississippi River Commission; Carrollton, 1879–'80, Mississippi River Commission.

The tables show the velocities, graduated in half feet, and the observed quantities of sediment during the several periods when each rate of velocity prevailed.

CARROLLTON, 1851–'52.

Velocity—feet per second.	Periods of observations.	Number of observations.	Extreme range of observations.	Mean grams of sediment in 600 grams water.
1.5 to 2.0	1st	13	104–282	.168
	2d	1		.092
2.0 to 2.5	1st	2	266–369	.317
	2d	2		.184
	3d	1		.192
2.5 to 3.0	1st	1		.414
	2d	1		.510
	3d	1		.097
3.0 to 3.5	1st	2	474–520	.497
	2d	1		.514
3.5 to 4.0	1st	1		.304
	2d	3	131–350	.207
	3d	1		.692
4.0 to 4.5	1st	1		.169
	2d	3	450–918	.636
	3d	1		.591
4.5 to 5.0	1st	5	197–276	.226
	2d	6	443–662	.557
5.0 to 5.5	1st	1		.614
5.5 to 6.0	1st	2	442–595	.518
	2d	2	241–271	.256
6.0 to 6.5	1st	1		.346

COLUMBUS, 1858.

Velocity—feet per second.	Periods of observations.	Number of observations.	Extreme range of observations.	Mean sediment Troy grains per cubic foot.
1.5 to 2.0		22	44–221	131
2.0 to 2.5	1st	8	155–420	233
	2d	8	125–258	188
	3d	1		354
2.5 to 3.0	1st	3	472–708	605
	2d	1		281
3.0 to 3.5	1st	5	422–598	535
	2d	1		502
3.5 to 4.0	1st	10	465–664	603
	2d	3	280–391	325
	3d	5	383–628	502
	4th	3	317–376	347
4.0 to 4.5	1st	2	605–641	623
	2d	2	406–738	572
	3d	2	140–266	203
	4th	3	354–487	421
4.5 to 5.0	1st	2	269–378	323
	2d	1		269
	3d	3	524–567	541
	4th	5	332–797	564
5.0 to 5.5	1st	1		346
	2d	1		280
	3d	1		635
5.5 to 6.0	1st	2	235–279	257
	2d	1		539
6.0 to 6.5	1st	1		288
	2d	1		490
6.5 to 7.0	1st	1		288
	2d	5	147–294	204
	3d	1		199
7.0 to 7.5	1st	4	211–307	264
	2d	2	470–538	504
	3d	1		278
	4th	2	235–382	308
	5th	1		155
7.5 to 8.0	1st	1		258
8.0 to 8.5	1st	1		355
	2d	4		323

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COLUMBUS, 1879.

Velocity—feet per second.	Periods of observations.	Number of observations.	Extreme range of observations.	Grams per cubic foot.
2.0 to 2.5	1st	3	22 - 37	29
2.5 to 3.0	1st	17	24 - 65	41.4
	2d	4	27.5- 30	28.6
3.0 to 3.5	1st	23	29 -110.5	57.2
3.5 to 4.0	1st	3	5 - 6.5	5.5
	2d	2	146 -146	146
4.0 to 4.5	1st	5	5 - 7	6
	2d	2	22 - 27	24.5
4.5 to 5.0	1st	1		34.5
	2d	5	27 - 55	37
5.0 to 5.5	1st	2	11 - 12	11.5
	2d	2	42 - 47.5	44.75

FULTON, 1879–'80.

Velocity—feet per second.	Periods of observations.	Number of observations.	Extreme range of observations.	Mean sediment m. gr. in 500 c. centimeters.
2.0 to 2.5	1st	11	265–420	339
	2d	14	295–500	361
2.5 to 3.0	1st	9	448–580	511
	2d	4	280–385	311
	3d	5	405–465	434
3.0 to 3.5	1st	4	230–470	311
	2d	6	505–820	647
	3d	9	410–640	524
3.5 to 4.0	1st	1		290
	2d	8	240–310	271
	3d	4	705–855	754
4.0 to 4.5	1st	3	210–220	215
	2d	4	330–440	386
	3d	4	265–310	281
	4th	12	435–640	538
	5th	2	860–790	825
4.5 to 5.0	1st	2	215–265	240
	2d	2		460
	3d	4	430–450	439
	4th	5	570–950	777
	5th	3	560–935	758
5.0 to 5.5	1st	1		390
	2d	2	880–890	885
	3d	3	850–945	908
5.5 to 6.0	1st	1		235
	2d	1		530
	3d	8	360–710	536
	4th	1		355
	5th	2	860–970	915
	6th	3	750–850	813
6.0 to 6.5	1st	1		335
	2d	1		200
	3d	6	215–395	317
	4th	1		380
	5th	1		275
	6th	5	965–1165	1062
	7th	1		840
6.5 to 7.0	1st	1		410
	2d	1		260
	3d	1		180
	4th	4		600
	5th	1		1085
7.0 to 7.5	1st	3	280–550	400
	2d	3	410–700	562
	3d	2	140–140	140
7.5 to 8.0	1st	1		325
	2d	2		145

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CARROLLTON, 1879–'80.

Velocity—feet per second.	Periods of observations.	Number of observations.	Extreme range of observations.	Mean sediment m. gr. in 500 c. centimeters.
1.5 to 2.0	1st	1		175
	2d	2	125–168	146
2.0 to 2.5	1st	3	245–375	313
	2d	3	190–190	190
2.5 to 3.0	1st	2	390–500	445
3.0 to 3.5	1st	1		400
	2d	1		322
	3d	1		470
3.5 to 4.0	1st	2	266–282	274
	2d	2	336–380	358
	3d	1		574
4.0 to 4.5	1st	1		670
	2d	1		230
	3d	2	506–536	521
4.5 to 5.0	1st	1		314
	2d	1		214
5.0 to 5.5	1st	1		536
	2d	1		218
5.5 to 6.0	1st	2	370–386	388

The extreme results of these observations can be condensed as follows:

CARROLLTON, 1851–'52.

Date.	Gauge.	Discharge, cubic feet per second.	Velocity, feet per second.	Proportions of sediment by weight.	Total pounds of sediment.
January 21	5.	482,392	3.	1/1177	25,616
June (third week)	11.6	779,384	4.40	1/874	74,482
April 1	15.25	1,112,559	5.96	1/2250	27,924

COLUMBUS, 1858.

August 30	13.	267,700	2.55	1/810	27,027
July 22	23.7	596,350	4.64	1/870	67,899
June 28	38.	1,156,960	7.23	1/2333	25,618
June 14	39.8	1,318,733	8.04	1/1364	60,850

COLUMBUS, 1879.

July 2	23.4	410,000	3.75	1/1025	131,835
April 5	33.65	720,000	5.20	1/2400	18,078

FULTON, 1879–'80.

July 31	168.25	340,000	3.5	1/810	34,836
March 28	188.	1,070,000	7.75	1/2333	19,367

CARROLLTON, 1879–'80.

August 19	2.	315,000	2.36	1/1333	14,769
August 9	4.40	425,000	2.93	1/1111	23,909
May 19	13.40	850,000	5.34	1/2105	23,047

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These results, which cover all observations on the subject, clearly give no support to the statement that the charge of sediment in the Lower Mississippi is proportioned to the velocity, nor do they admit of explanation by the suggested effect of depth in modifying the relation between these two functions. There is, however, no obscurity in the cause of these apparent anomalies. The stage of the Missouri and other silt-bearing tributaries, in relation to that of the clear-water tributaries, is evidently the influence most largely controlling the amount found at any time in the river. High water from the Missouri is heavily charged with sediment even to the Gulf, while from the Ohio there is but little sediment, with equal or greater heights and velocities.

Under these conditions the law governing the relation between velocity and sediment is no further useful than was stated in the first report of the Commission:

"Any reduction of velocity, by lessening the sustaining and transporting power of water, and by arresting some of the heavier particles which the diminished current is unable to move along the bottom, will tend to cause a deposit of solid earthy matter and raise the bed of the stream."

But even if the adjustment of sediment to velocity is admitted, the caving of banks would still continue as the direct effect of the impact of the current. This is clearly shown by the results of comparative surveys below Cairo. There the demarkation between the muddy discharge from the Mississippi and the clear water from the Ohio while flowing side by side is sharply defined. It is frequently observable by the eye for a distance of twenty or thirty miles and by the sediment trap for a distance of two or three hundred miles. Yet the caving on the right bank washed by water more heavily charged with sediment exceeds that on the left bank, as is shown by the following table, constructed from comparative surveys by the Commission, covering a peroid of four years:

Length of river below Cairo.	Right bank.		Left bank.	
	Length of erosion.	Area annually eroded.	Length of erosion.	Area annually eroded.
	Feet.	*Sq. ft.*	*Feet.*	*Sq. ft.*
25 miles	35,000	2,345,000	20,000	1,740,000
50 miles	78,900	6,285,600	55,500	3,000,000
75 miles	110,200	8,633,100	75,500	5,720,000
110 miles	186,650	17,443,350	179,000	15,018,300
150 miles	268,350	28,382,150	260,300	27,062,700
200 miles	344,650	35,797,050	279,300	28,848,700
To Memphis	390,650	41,709,350	332,300	35,471,700

The conclusion is thus reached that the amount of sediment is not mainly controlled by the velocity nor the amount of caving by the degree of sediment saturation of the passing current.

The same conclusion is reached by any logical arrangement of all the observed facts.

By the terms of the theory of the development of an alluvial stream, its bed and banks are shaped and built by its own forces with a uniform section, in regimen with its other elements. The dimensions are adjusted to the slope and discharge, and the bed approximates such form as offers least resistance. The river, therefore, in its normal condition, realized the correction which is now proposed for its regularization. Then why has this ideal state been disturbed by caving, and why are artificial means now required to restore, or even maintain, a natural condition?

Assuming that the proposed correction had been applied, giving uniform width and velocity, and that in consequence caving was checked, we should then have less sediment by the amount thereof now contributed by caving banks and a velocity greater because relieved from the work of suspending and transporting that amount of sediment. Under these conditions why should not erosion be increased rather than diminished if the theory under discussion is true?

Again, uniformity of section affects only mean velocity. The extremes would still vary greatly after all the contraction necessary for navigation was accomplished. Along the bank, as it is concave or convex, the current would still flow with the same alternations of velocity as at present, and with the same differences of sediment predicated by the theory. The fill and scour of the bank would therefore continue.

From experience it is known that a deposit up to the height of the high-water bank cannot be induced by contraction works in less than four or five years; also, from experience and the terms of the theory, caving will not cease until the high-water contraction is complete. During the period of construction caving will continue,

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and the line of the new shore, and the contraction works defining it, must be annually advanced at an equal rate. If they are not, by the time complete results are attained on the original line the river will have recovered the width that first made contraction necessary. If the line is thus annually advanced the cost of contraction will soon largely exceed that of bank protection.

Probably more than half the material contributed by caving is from the bank above the limit of erosion or the water surface. The weight and bulk increase in a greater ratio than the height. Therefore an undue proportion is contributed at low water and where the banks are high. For this reason an illustration taken from the river when the rise and fall is small, as at Fort Saint Philip, is unfair, particularly as it is known that the soil, as we proceed down the river, becomes less sandy and more tenacious.

If this theory were correct the greater caving would occur during the rise of the river, which is a period of increasing velocities. But it is well known that the reverse of this is true, and that caving is excessive during the falling river in a period of decreasing velocities.

While it is true that the caving is less below than above Red River it cannot be accounted for by greater uniformity of velocity. The great depth allows and the small width compels a general movement of the mass approximately parallel to the axis of the bed. Above Red River the immense bars lying athwart the channel and the great width of the bed directs the entire volume against the bank. This action is mainly developed during the falling and low stages, when the caving is observed to be the most extensive.

This theory can be here left as unproved by the facts and insufficient to account for the results.

To the caving of banks can be attributed, in great part, the deterioration of the river, both as a navigable channel and as a drainage line; and also the difficulties encountered in the improvement of either of these functions. In the first place, by caving, both the length and the high-water width of the river is increased. Although the deposit on the convex or growing side may be equal, in any given time, to the amount caved away from the opposite bank, yet these two masses of material are of such relatively different shapes that their opposite movements, one of accumulation and the other of waste, give as a net result an increased width of river. The material from the convex bank, precipitated into the swiftest current of the river, is promptly swept away. The opposite side of the bed, being higher, is less deeply submerged and by water less rich in sediment. Therefore, while the extension of the new deposit out into the channel may be as rapid as the recession of the opposite shore, its elevation to the normal bank height of the river is very gradual.

All exact observations confirm a conclusion which is sufficiently obvious from a general knowledge of the river. The most important of these are appended in tabulated form:

Locality.	Distances.	Time.	No. of widths.	Mean increase.	Per cent.	Authority.
	Miles.		*Feet.*	*Feet.*		
Cairo to New Orleans.....	963	1821 to 1874, 53 years.	319	1,813	.74	Poussin, U. S. Rec. Suter, U. S. Rec.
Cairo to New Orleans.....	963	1851 to 1874, 23 years.	219 319	1,219	.40	H. & A. Hyd. Miss. Suter, U. S. Rec.
Coles Creek to Tunica.....	100	1851 to 1883, 32 years.	11	334	.105	H. & A. Hyd. Miss. Miss. Riv. Com.
Baton Rouge to Donaldsonville.	52	1851 to 1883, 32 years.	68	149	.053	H. & A. Hyd. Miss. Miss. Riv. Com.
Point Houma to New Orleans.	75	1851 to 1875, 24 years.	40	66	.03	H. & A. Hyd. Miss. Maps U. S. C. & G. S.

The first instance probably gives an excessive result from the vagueness of the earlier authority. The two last are in parts of the river where changes are very much slower than above Red River; but the general movement is established. Instances of caving of 1,000 feet per year are not unknown:

As the width of the river increases its mean depth diminishes. Continued widening develops a very characteristic shape of bed, in which the deepest water is along both banks, and a middle ground or bar area at the intermediate node or reversion point between bends. The absence of defined channels across this bar area from one pool to another is the obstruction to low-water navigation. The development of channels through it is the result of the relative increase of local velocity by the reduction of area as the water falls at the bars. If these channels increase in number, as frequently occurs, they become tortuous, uncertain, and the navigable depth in each diminishes. The physics of this bar formation, characteristic of all natural

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water-courses with yielding beds, is discussed by Major Suter (Report Chief Engineers, 1881, p. 1649), and by Professor Mitchell (Report Mississippi River Commission, 1882, Appendix S, p. 263), to which papers I beg leave to refer.

Two results of much importance in the improvement of navigation follow these conditions.

(1) As the shape of a bend changes by caving a new direction is constantly given to the maximum scouring effort of the river, by which a low-water channel or crossing is developed through the bar at the node below. Hence it is impossible to "permanently locate" this channel until the shore-line of the bend above is fixed. If contraction works are located at any time with reference to existing currents and channels, their continued usefulness depends upon the maintenance of the direction of these currents. Professor Mitchell says: "These bars are not permanent in position; on the contrary they are prone to shift as the bends become more acute, extend, or move downwards. Indeed, under the general rule that the bars form at the reversion point of curves, it is evident that their positions must vary as these curves vary, and that the holding of the curves, by revetment or otherwise, is an essentially early step in the control of the river. It antedates logically the retrenchment which is to deepen the water at the bars."

(2) The continued change in the shape of a bend by caving and of the location of the crossing below, which marks the thread of movement of the stream, necessarily changes the direction in which the current enters the bend below. Hence, this is subjected to new and shifting attacks, and the ill effects of caving in an upper bend is transmitted downwards in turn from bend to bend. It is fair to infer that if the caving in any one bend were arrested the transmitted effect below would ultimate itself and cease. As it is, the increase of caving is in a compound rather than a simple ratio.

In the next place, from caving banks is derived a large part of the material of which bars are composed. If the results of the observations by the Commission on caving banks be prorated over the length of the river below Cairo, omitting any consideration of the part below Red River, for safety in estimating, and a mean depth of 100 feet be assumed for the caving, then the amount contributed from this source is about four times as great as the sediment discharge of the river as computed by Humphreys and Abbot.

The banks are, generally speaking, of sand and clay, seldom purely of either material, but mixed in different proportions, according to the conditions under which they were built. When they yield to the encroachment of the river, the finer and lighter portions readily float long distances with low velocities, and are mainly deposited in quiet water, under the shelter of willow points. The sediment from the Missouri floats so readily that at times, at a distance of 1,200 miles below its mouth, at medium and low stages, and correspondingly small velocities, not only the charge of sediment per unit of measure, but even the total bulk afloat is greater than at times of great flood from the Ohio, when the discharge and velocity are approximately doubled. But the more important part, both in quantity and function, the sand and fine gravel, sinks rapidly, forming a loose and movable bed, which is shaped into sand waves and bars by the forces of the river, constantly changing in direction and intensity. If it falls in a pool where the scouring power of the higher stages is concentrated, the next flood sweeps it down to the bars on the wider section below, where the current spreads and its transporting power abates. From this halting place, where the current becomes relatively greater as the lower stages are reached, it is scoured down into the comparatively still pool below. The range of elevation of these bars during the annual oscillation of the river frequently exceeds the depth found on them at low water. A high-water survey, reduced to low-water gauge-readings, would exhibit numerous dry bars extending entirely across the bed. The more important down-stream movement of sediment is, therefore, intermittent, and it can be understood that the same material may enter successively into the composition of each bar as it moves by semi-annual excursions toward the sea.

Besides these uses for bank revetment, which may be classed as conservative, I assign it another duty, in restoring that uniformity of section and velocity, which is of obvious importance in the regularization of rivers. The extreme variations of width now existing, with a tendency toward further increase, are not normal, but are exaggerated by caving. The physical history of the river is not one of growth from a narrow to a wide stream, but of the replacement of a much wider expansion of surface by a defined and limited water-way, of an estuary by a river. The bed still strives to conform its dimensions to the smallest section that will contain the volume flowing through it, and to a shape that will offer least resistance. The reversion of this process, as is now observed, marks the presence and control of abnormal influences. It is therefore just to expect that when the elongation of points and the growth of middle bars is resisted by the establishment of permanent banks, the material now used in their extension toward the retreating bank will be deposited over areas outside of the required bed limits so as to raise them up to bank level, and thus,

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by narrowing the bed, restore more favorable conditions both for navigation and discharge.

As compared with contraction work by dikes or screens, I believe that bank protection, for any given length of river, is of not greater cost, while more rapid in construction; can be made more enduring, as less exposed to drift, ice, and the alternations of wetting and drying; and its ultimate effect in adjusting widths and sections will be equally certain and more permanent than dike-work. Besides this, while even from experience it is obvious that the necessity for the protection of caving banks is not obviated or reduced by dike-work, it may be justly expected, from reasons before given, that permanence of bank, and, consequently, of channel, will have effects that will to some extent reduce the amount of artificial contraction required. The obvious illustration of this is the exceedingly narrow and deep sections along the foot of bluffs at Columbus, Fulton, Randolph, Memphis, the old Vicksburg and Grand Gulf channels, and at the other points below. Acknowledging entirely the importance to navigation of an equalization of width, the prevention of caving is a certain, permanent, and economical way of securing it. I therefore recommend the completion of this part of the work from Saint Louis to Cairo, and its commencement at Cairo and extension down river, in bends where, in the judgment of the Commission, caving is rapid enough to be injurious to navigation by widening or preventing the permanent location of the channel or by increasing the supply of bar material. This general order of progress is proper, because the work secures itself from attack from above as it progresses, and is constantly exerting a conservative and beneficial influence through the reaches below. It may, however, at times be advisable to anticipate the general progress of the work where very disastrous caving is going on, and particularly where a cut-off or the destruction of a harbor or important contraction works is threatened. It must not be forgotten that if bank protection is continued as part of the plan of improvement the results of dike-work will become slower, and therefore more costly, since the supply of sediment which the latter is intended to arrest will be diminished by the extensive application of the former. To a certain extent choice must be made between the two methods. Without permanent banks contraction is impracticable. With permanent banks, the channel will be directly improved, and a certain amount of contraction will naturally result.

B. M. HARROD.

NEW ORLEANS, *February*, 1885.

APPENDIX C.

ANNUAL REPORT OF THE SECRETARY OF THE COMMISSION UPON THE WORK OF SURVEYS AND EXAMINATIONS.

OFFICE OF MISSISSIPPI RIVER COMMISSION,
2828 WASHINGTON AVENUE,
Saint Louis, June 18, 1885.

GENERAL: I have the honor to submit the following report of the work of the secretary's office and of surveys and examinations during the fiscal year ending June 30, 1885.

My duties as secretary only began upon March 3, when I relieved Capt. Smith S. Leach, Corps of Engineers, who had performed those duties from August, 1879, to that time.

The operations carried on under this office for the past year have been the inspection and repair of gauges on the main river below Saint Louis and on tributaries; the checking, compilation, and publication of gauge records; field work of topography and hydrography; the reduction and plotting of field notes, and the preparation, publication, and distribution of maps; the printing of tabulated data, gauge records, proceedings of the Commission and reports; observations for computing the discharge of the main river at six selected points below Cairo, and of the Atchafalaya near its head, and of Old River between the head of the Atchafalaya and the Mississippi; the reduction of the notes of these observations, and the computations therefrom; various local examinations made by the assistant with the steamer Patrol and in charge of inspection and repair of gauges and bulletins; tidal observations to determine the mean gulf level upon a gauge established near Biloxi, Miss.; the reduction and compilation of physical data of the Mississippi River and the Alluvial Valley; the classification and filing of the reports and records pertaining to the Commission; the disbursements of the funds appropriated for the expenses of the Commission, and for surveys under its direction, and the clerical work rendered necessary by these duties.

For purposes of organization and to systematize the labor, the office work, as was

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noted and described in the last annual report of the secretary, is distributed and allotted to divisions, with assistants in charge of each.

The topographical division is in charge of Mr. J. A. Ockerson, assistant engineer, and there have been associated with him Assistants C. M. Winchell, C. W. Clark, Moses Greenwood, jr., O. W. Ferguson, O. A. Orrman, F. B. Maltby, and J. T. Desmond. Mr. Edward M olitor has been employed throughout the year in this department in drawing and preparing charts for publication and engraving sheets of titles, notes, and table of distances to accompany published series of maps.

The computing division is in charge of Mr. L. L. Wheeler, assistant engineer, and there have been attached to this division, either throughout the year or in the intervals between field duties, Assistants Kivas Tully, T. C. Thomas, L. C. Jones, J. W. Dorst, H. P. Ritter, G. W. Wood, and H. B. Wood.

The field work of topography performed was executed by Mr. C. M. Winchell, assistant engineer, having under his orders Assistants C. W. Clark, O. W. Ferguson, H. B. Wood, L. C. Jones, H. W. Kerr, F. B. Maltby, O. A. Orrman, Moses Greenwood, jr., G. H. French, and Recorders D. E. Perkins and Isaac Purcell.

The inspection and repair of gauges has remained in charge of Assistant John Ewens, and the parties making discharge observations were in charge of Assistants E. E. Haskell, G. W. Wood, A. H. Weber, J. W. Dorst, Homer P. Ritter, and M. K. Bowen.

FIELD WORK OF TOPOGRAPHY AND HYDROGRAPHY.

This consisted of the completion of topography below Cairo, with a line of levels, filling in the gap existing between the point near the Kentucky-Tennessee state line where work of the preceding season ended and Caruthersville, Mo., closing on the upper limit of Assistant L. L. Wheeler's work of 1883–'84, a distance of about 46 miles; of the completion of the survey of Reelfoot Lake and the bluffs behind it, begun the year before, and of a survey from Grand Tower down to Hacker Towhead, 25 miles above Cairo, a distance of about 52 miles, and extending down the right bank to Buffalo Island, half a mile farther. A field report of this work, made by Mr. Winchell June 12, 1885, is appended hereto, and attention is invited to it and to its attached list of bench-marks established from Grand Tower to Buffalo Island.

PREPARATION AND PUBLICATION OF MAPS.

From the date of the last report of the secretary to the end of the fiscal year the following, adapted from a memorandum furnished by Mr. Ockerson, assistant engineer, shows the progress made in this department. Eleven detail charts, scale 1: 10,000, extending from the head of Bordeaux Chute to Saint Louis Landing, a distance of 71 miles, have been finished except the titles and notes. The topographical signs have been printed on nineteen charts in addition to the above. Eighteen detail charts have been projected, and sixteen of them have been transferred and the outlines have been inked. Twelve of these charts lie between Grand Tower and Cairo, and six lie between New Madrid and Caruthersville. The latter were also lettered. Twenty-three detail charts, scale 1: 10,000, covering the following Old River lakes and tributaries, have been projected and finished, with the exception of titles and notes: Bayou de Chien and bluffs, below Hickman, Ky.; Flower Lake, Beaver Dam Lake, Moon Lake, Horseshoe Lake, and head of Sunflower River, Lake Lee, Bunch's Lake, Lake Providence, Eagle Lake, Yazoo Lake, Lake Saint Joseph, Lake Bruin, Lake Saint John, and Lake Concordia, each in one chart; Saint Francis River from opposite Walnut Bend to mouth, Palmyra Lake, and Red River from opposite Black Hawk Landing to mouth, each in two charts, and Reelfoot Lake in three charts. Four sheets of the series on a scale of 1 to 20,000 have been published; two of them are in the vicinity of Saint Louis Landing, and two covering the Lake Providence Reach. Nine sheets of this series have been published so far, and the material has been prepared for thirty others. These two items embrace that portion of the river extending from Island No. 63 to Donaldsonville, a distance of 550 miles. The index charts, titles, and scales for the same series for twenty-eight sheets above Island No. 63 have also been completed.

The positions of stone line bench-marks have been computed and tabulated from New Madrid to Caruthersville and Saint Louis Landing to Leota. This embraces some fifty-six stone lines and two hundred and twenty bench-marks.

Work on the preliminary chart—scale, 1 inch to 1 mile—has been continued. One sheet near the Head of the Passes has been completed, and a part of one sheet near Donaldsonville. One title-page and one sheet of notes, table of distances, &c., have been engraved. Three index-sheets have been prepared for photolithographing. Six sheets from Jackson's Point to Donaldsonville, one sheet at the Head of the Passes, and two sheets of titles and notes have been printed.

A map of the Alluvial Valley was commenced, which will show the area overflowed, and will exhibit sections across the alluvial region referred to the level of the gulf as

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a datum plane, and the water-surface of the overflow of 18-2 will be indicated upon the sections. The map will in addition show the lines of levees in existence, besides other features of note, and will give much information of interest and value. The map comprises eight sheets, each 22 by 29 inches, on a scale of 1 inch to 5 miles, and extends from Cape Girardeau on the north to the Gulf of Mexico, and is of sufficient width to embrace the several basins of the lower river. The river and adjacent detail is derived from the recent surveys made by the Mississippi River Commission, General Comstock and the United States Coast Survey; the transalluvial profiles are from surveys of the Mississippi River Commission, Humphreys and Abbot, and railroads. The remainder of the map is derived from maps of various kinds, embracing the best data extant. It will soon be ready for printing. The following summary, indicating the condition and progress of the work upon the charts, is of interest.

The outline series embraces shore-lines and soundings, with a strip of say 200 or 300 meters of topography, from Island No. 1 to the head of Frame's Chute, joining General Comstock's previous survey, 36 charts; from Commerce Cut-off to O. K. Landing, joining General Comstock's previous survey, 4 charts; and from Delta, Miss., to Saint Louis Landing, joining at its upper end General Comstock's previous survey, 5 charts; making a total of 45 outline charts, of which 14 are completed with titles, notes, &c., and 31 require only the titles and notes.

The topographical series cover the region from Island No. 1 to the head of Frame's Chute, 34 charts; from Commerce Cut-off to Donaldsonville, 101 charts; and from Grand Tower to Hacker Towhead, 12 charts; making a total of 147 charts, of which 100 are finished except titles, &c., the conventional signs are required on 28 charts, the lettering on 10 charts, the outlines are yet to be inked on 2 charts, and the titles, notes, &c., are required on all of them.

The Old River Lakes comprise 23 charts, all of which are finished except titles, &c.

The series, on a scale of 1 to 20,000, will comprise 67 charts besides index, titles, &c., of which 9 are published and the material is prepared for 30 others, all below Island 63, and the index charts, titles, and scales for 28 sheets above Island 63 are completed.

The preliminary map, scale 1 inch to 1 mile, comprising 32 sheets, 3 index sheets, and 2 sheets of titles and notes, is all printed except the 3 index sheets, now ready for photolithographing, and the series will be complete for distribution in a few weeks.

The compilation of stone line bench-marks is completed from Cairo to Leota, 512 miles, leaving the 372 miles from Leota to Donaldsonville yet to do.

The series, on a scale of 1 to 10,000, will comprise 215 manuscript charts, of which 168 are finished except titles, &c.

In this department the printing of conventional signs upon the manuscript maps, alluded to and described in the last annual report, has been continued and perfected, and it is the intention to submit a supplementary report with description and illustrations compiled by Mr. Ockerson, the chief of the topographical division.

DISCHARGE OBSERVATIONS.

Preparations for this work were begun in August, the principal parts of the meter plant were designed, and this plant and three iron launches, similar to those previously used, but having double engines, were ordered. The parties were in the field at about the end of September, being stationed as follows:

Near New Madrid (Point Pleasant, Mo.), in charge of Assistant E. E. Haskell.

At Helena, in charge of Assistant A. H. Weber.

At Arkansas City, in charge of Assistant G. W. Wood.

At Warrenton, in charge of Assistant J. W. Dorst.

At Red River Landing, in charge of Assistant H. P. Ritter.

At Carrollton, in charge of Assistant M. K. Bowen.

The observations at Red River Landing embrace measurements of discharge of the Mississippi River below the mouth of Red River, of the Atchafalaya near its head, and of Old River between the Atchafalaya and the Mississippi.

Work at all the stations was continued throughout the winter, with many interruptions from running ice in the upper river and from heavy winds and fogs below. No appropriations having been made in the late session of Congress, the cessation of this work became necessary, and at the end of March the withdrawal and disbanding of the parties were ordered, the services of Assistants H. P. Ritter, E. E. Haskell, and G. W. Wood being retained. The reduction of the notes of these observations is now in hand, and when completed the results, with reports, will be presented for publication.

An attempt was made to make comparative observations for discharge with meters and double floats, but the compulsory withdrawal of the parties interrupted them before they were fairly inaugurated.

GAUGE INSPECTION.

Experience has demonstrated that the records of a series of gauges become very unreliable, and in many instances entirely useless, unless the gauges be subjected to

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frequent inspections to check the recorded readings of the observers, to replace disturbed or lost sections of the gauges, and to check the elevations of the divisions by connecting them instrumentally with established bench-marks. These inspections have been made, as heretofore, by Assistant John Ewens, who determines the error, if any, existing in the elevations on the gauges, repairs the gauges and the bulletins, and reports the result of each inspection of each gauge to this office, by which the reported readings are checked. The steamer Patrol, built for that purpose principally, had been used for visiting the gauges up to the end of April, when lack of funds compelled us to lay the boat up and disband the crew. Since that time arrangements have been made to visit the gauges, making use of the passenger steamers and other modes of travel. Mr. Ewens takes with him one man, to assist, with a level, and such smaller tools as are found necessary, a maul, driving-cap, and a small supply of lumber being sent to each station for use as required. Seven gauges, deemed of least importance or most troublesome, have been discontinued from lack of funds. Weekly reports are rendered by each observer, the readings are plotted and examined in the computing division, and any found in error are reported and the observer called upon to repeat the record.

The year of observation of the tide-gauge at Biloxi, Miss., ceased on June 10, and the property pertaining to the station was shipped to this office.

OPERATIONS OF THE STEAMER PATROL.

The report of the Secretary in the annual report of the Commission for 1884 explains the necessity for this boat. During the last fiscal year it has been used for transporting Assistant Ewens, in charge of gauge inspections, from point to point, which are its regular duties. By its use examinations were permitted of Waterproof Cut-off and surveys in front of the Davis and Bonnet Carré crevasses, soundings at shoals or crossings were made in July and August, and snags discovered in the channel were reported. Two launches were towed from Cairo to Saint Louis for repairs in August. During the entire month of September and up to the middle of October the boat was engaged in distributing launches and quarter-boats for the observation parties, transporting subsistence and supplies for the topographical party, and in towing the new launches from Dubuque to their stations, passing over the river from Saint Louis to Vicksburg and return, thence to Dubuque, and down the river to New Orleans. By its use low-water benches were connected below Vicksburg to Red River Landing, and the Commission were transported in an examination of the Atchafalaya. On December 30 the boat was forced from Cairo up the Mississippi River for 25 miles, and returned with the topographical-survey boats, which were in an unsafe location. With the Patrol the Secretary made an inspection of the field and office work at the six discharge stations in January, rating the meters according to an improved method. The steamer was used in March to transport Assistant L. L. Wheeler, accompanied by Assistant F. B. Maltby, down the river for the purpose of making experimental observations with meters and double floats, and when the observation parties were recalled it was used to tow the launches and quarter-boats of the five lower stations to Twin Hollows. While performing these special or incidental duties the gauges were inspected as necessity seemed to require, and repairs made. One hundred and eleven gauge visitations were made July to April, inclusive, none being made in September. The number of visits made per month varied from five to twenty-four, and the visits to individual gauges in the entire time varied from one to ten.

Attention is invited to the fact that when the survey boat Pioneer was sunk, as noted in Mr. Winchell's report, several of the assistants lost considerable personal property, consisting of clothing, professional books, &c. This loss was incident to the service upon which they were engaged, was entirely without fault of theirs, and due to causes beyond their control, and remuneration would seem to be but just and proper.

The failure of additional appropriations has rendered a reduction of force necessary, which was much to be regretted, and has caused a cessation of important work, and will make it impossible to provide for valuable observations and operations during the coming season and in the next period of high water and probable overflow. Other matters will be reported on from time to time and reports forwarded as the material is prepared and completed.

Very respectfully, your obedient servant,

THOMAS TURTLE,
Captain of Engineers,
Secretary Mississippi River Commission.

General Q. A. GILLMORE,
President Mississippi River Commission.

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Itemized statement of expenditures for Mississippi River Commission, appropriation of July 7, 1884.

Items.	Services assistant engineers, &c.	Services rodman, &c.	Outfit.	Supplies.	Subsistence.	Fuel.	Repairs.	Transportation.	Mileage and traveling expenses.	Miscellaneous.	Totals.
Salaries of commissioners											$9,000 00
Mileage and inspection		$1,290 60		$18 74	$1,217 41	$961 31		$52 75	$3,063 23		6,604 04
Salaries and traveling expenses of assistant engineers	$28,511 13							297 65	86 65		28,895 43
Publication of maps	1,522 45			1 40				2 10		$415 50	1,941 45
Gauges	185 00	1,319 34	$15 45	24 82	85 13	126 50	$21 64	19 70			1,797 58
High and low water marks		245 80	25 65	98 60	181 35	299 50	137 77	13 15	5 71	13 50	1,021 03
Reduction of field work	1,563 87	1,591 96	99 66	71 05				20 30			3,346 84
Hydrography and topography	72 35	484 50		33 00							589 85
Totals	$31,854 80	4,932 20	140 76	247 61	1,483 89	1,387 31	159 41	405 65	3,155 59	429 00	53,196 22
Office:											
Services clerks, &c										8,726 58	
Rent										1,200 00	
Fuel										393 19	
Professional works, &c										22 20	
Furniture										43 67	
Supplies										218 96	
Transportation										174 12	
Stationery										518 83	
Telegrams										106 94	
Miscellaneous										237 41	
											11,677 90
											$64,874 12

SUMMARY.

Balance from appropriation March 3, 1883	$12,528 61
Appropriation by act July 7, 1884	75,000 00
Cash deposited, sale of fuel to officers	66 75
Total	87,595 36
Expenditures for fiscal year ending June 30, 1885	64,874 12
Balance	22,721 24

THOMAS TURTLE,
Captain of Engineers,
Secretary and Disbursing Officer Mississippi River Commission.

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Itemized statement of expenditures for surveys of Mississippi River, act of July 5, 1884.

Items.	Services assistant engineer, &c.	Services draughtsmen, rodmen, &c.	Outfit.	Supplies.	Subsistence.	Fuel.	Repairs.	Transportation.	Traveling expenses.	Miscellaneous.	Medical supplies.	Totals.
Observations	$9,999 76	$52 00	$9,654 01	$899 69	.....	$940 81	$1,370 62	$1,345 51	$13 80	$67 50	$16 30	$24,360 00
Publication of maps	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	854 50
Reduction and publication	2,565 00	830 00	223 79	458 64	.....	.....	.....	34 92	.....	50	.....	4,112 85
Field work of topography	5,596 71	.....	91 58	846 72	$1,548 01	147 46	780 90	604 42	.....	7 50	.....	9,623 30
Inspection and maintenance of gauges	7,306 75	1,319 34	724 87	561 76	963 74	1,828 86	930 51	23 80	.....	192 25	74 45	13,926 33
Miscellaneous surveys	.. ..	2,317 74	74 86	195 49	262 57	998 65	45 85	105 70	8 85	53 70	.....	4,063 41
Care of property	.....	1,676 00	79 65	118 89	.....	.....	.....	36 50	.....	.....	.....	1,911 04
Totals	25,468 22	6,195 08	10,848 76	3,081 19	2,774 32	3,915 78	3,127 88	2,150 85	22 65	321 45	90 75	58,851 43

SUMMARY.

Appropriation by act July 5, 1884	$75,000 00
Expenditures for fiscal year ending June 30, 1885	58,851 43
Balance	16,148 57

THOMAS TURTLE,
Captain of Engineers,
Secretary and Disbursing Officer Mississippi River Commission.

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Approximate value of plant belonging to the United States and used by the Mississippi River Commission in making surveys and examinations of the Mississippi River, appropriation "Mississippi River Commission."

Class of property.	Approximate value June 30, 1885.
One steamer, Patrol	$14,600 15
Three launches, Nos. 1, 2, 3	6,000 00
One steam-tug, Frolic	2,000 00
Seven quarter-boats	15,310 35
Skiffs, &c	800 00
Outfit	5,232 58
Tools and appliances	1,063 22
Surveying instruments	12,641 76
Drawing instruments	773 60
Office furniture	851 25
Printing press, &c	325 05
Current meters and outfit	1,976 50
Total	61,574 46

Appropriation, "Surveys of Mississippi River".

Class of property.	Approximate value June 30, 1885.
Three launches, Nos. 4, 5, and 6	$8,286 00
Current meters and outfit	884 00
Outfit	271 71
Tools and appliances	138 70
Total	9,580 41

Respectfully submitted.

THOMAS TURTLE,
Captain of Engineers,
Secretary Mississippi River Commission.

SAINT LOUIS, *July* 23, 1885.

C 1.

REPORT OF C. M. WINCHELL, ASSISTANT ENGINEER, ON FIELD WORK OF TOPOGRAPHY AND HYDROGRAPHY.

OFFICE MISSISSIPPI RIVER COMMISSION,
2828 WASHINGTON AVENUE,
Saint Louis, June 12, 1885.

SIR: I have the honor to submit the following report on the field-work of the topographical party under my direction during the season of 1884-'85:

In obedience to instructions from Capt. Smith S. Leach, Secretary Mississippi River Commission, I left Saint Louis September 27, 1884, with the following assistants: C. W. Clark, O. W. Ferguson, H. B. Wood, L. C. Jones, H. W. Kerr, F. B. Maltby, O. A. Orrman, M. Greenwood, jr., G. H. French, and recorders D. E. Perkins and Isaac Purcell. The crew had been ordered to report at Cairo September 28.

The instructions directed me to go to Cairo, Ill., take the quarter-boats Tennessee and Pioneer and tug Frolic, and proceed to a point near the Kentucky-Tennessee State line to resume the survey where the work of the preceding season ended, and continue the same down the river to Caruthersville, Mo., closing on the upper limit of Assistant L. L. Wheeler's work of 1883-'84.

After finishing this reach I was directed to have the boats and party towed to Grand Tower, Ill., and make a survey of the river from there to Cairo, Ill., closing on the

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upper limit of the work of the United States Lake Survey of 1876-'77. We reached Cairo September 28, and went at once on board the quarter-boats. The Frolic was on the docks undergoing repairs. I therefore engaged the tug Ariadne to tow the boats, including Mr. Haskell's quarter-boat Kentucky and iron launch, to New Madrid, Mo., which point was reached September 30, and work began the same day. Topographer French and three men were landed at Hickman, Ky., September 29, with instructions to proceed to Reelfoot Lake and complete the survey of that lake and the bluffs behind it, which was begun the year before. The Frolic arrived from Cairo October 14, the party having been deprived of the services of a tug for fifteen days. One of the advantages of having a steam-tug with a party of this kind is shown by the different rate of progress made. In fifteen days without the Frolic the party surveyed 17 miles of river. During the next sixteen days with the Frolic we surveyed 29 miles. This gain is chiefly due to the saving of time in getting the field parties to and from work, about an hour being gained at each end of the day.

Mr. French rejoined the party October 15, having finished the survey of Reelfoot Lake and connected it with the main river survey. It was found necessary to carry a system of tertiary triangulation over this entire reach, to check the stadia work, the secondary triangulation stations, which were built in 1879-'80, being all caved in the river or destroyed except two at Island 14 and two at Island 15.

The survey was completed to Caruthersville November 1, previous to which date I had been directed by Captain Leach to wait at Caruthersville for the steamer Oakland to tow the quarter-boats to Grand Tower. The Oakland arrived and took the boats in tow on the evening of November 6, the time between the 1st and 6th being occupied by the party in office work, repairing and painting skiffs and stadias, scrubbing quarter-boats, and getting up a supply of stove-wood. About 10 p. m., October 6, when about one mile below Point Pleasant, Mo., the Pioneer ran under and sank, one end and part of one side of the cabin being carried away. The sinking was caused by pulling out of an eddy to pass a projecting clay point and suddenly encountering a very rapid current. There were a dozen men on the Pioneer at the time of the accident, part of them in bed, all of whom escaped by climbing out through the sky-lights, and were picked up in skiffs. We then succeeded in landing the wreck of the Pioneer near Lazelles Landing, Missouri, when I, with Topographer Ferguson and three men went ashore to recover what property we could from the wreck. all of the surveying instruments, transits, theodolites, levels, and level-rods being on the Pioneer, besides a good deal of personal property. The Oakland went on up the river with the other boats and the party, in charge of Assistant C. W. Clark. November 7 we recovered all the instruments except one Stackpole transit, and sent them at once to Grand Tower in charge of Mr. Ferguson. November 8, the United States steamer Mississippi arrived and raised the Pioneer when the missing transit was found under a stove. The Pioneer and what property was saved on her was left with Assistant E. E. Haskell, who was stationed at Point Pleasant, and whose receipt I took for the same. I left Point Pleasant November 10, and rejoined the party at Grand Tower November 12, stopping one day in Cairo to arrange for the towing to Grand Tower of the quarter-boat Mississippi to take the place of the Pioneer. The party reached Grand Tower November 8, and began work Monday, November 10, a part of the men being quartered at farm-houses until the Mississippi arrived November 17.

December 9, Topographer Maltby was taken sick with malarial fever, and on December 19, was sent home on sick leave. Recorder Perkins also went home, sick, on December 24.

December 17 the survey was completed to Hacker Towhead, below Commercial Point, Illinois, on which date ice began to run in the river rendering it impossible to cross the river in a skiff afterward for several weeks.

The work on the right bank was carried down to Buffalo Island, closing on stone-line No. 6, but there was no field work done after December 18.

From December 18 to December 30, the assistants were engaged in reducing field notes, plotting, &c., and the crew in felling and hauling trees from the neighboring woods to build log booms to prevent the boats from being cut down by the ice.

December 30, the United States steamer Patrol arrived with Captain Leach on board and the boats were taken to Cairo and laid up. The party was paid off and disbanded December 31, when I returned to Saint Louis with the assistants who were retained.

TOPOGRAPHY.

The usual topographic features were located, bayous, sloughs, swamps, fields, roads, and houses, the elevation of the ground being determined by vertical angles at nearly every point which was located to aid in sketching contours.

From September 30 to November 1, there were twenty-nine working days. The total area surveyed was 153¼ square miles or 5.3 square miles per working day. The

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length of main river surveyed is 46 miles, which gives a daily rate of progress of 1.6 miles.

On the upper reach, Grand Tower to Buffalo Island, the river follows the bluffs on the right bank to Cape Girardeau, where there is an opening in the bluffs extending to Gray's Point. This opening has a river front of 4 miles and is the first outlet for the Mississippi River floods to the Saint Francis Basin. From Gray's Point the bluffs border the river on both sides for a distance of 7 miles to Commerce, Mo., where they leave the river. On the left bank the bluffs from Grand Tower to Sexton Creek are from 3 to 5 miles east of the river. This line of hills was also located as well as numerous creeks and lakes between the bluffs and the river. On this reach of river the total area surveyed was 159 square miles. From November 10 to December 17 we had thirty-two working days, on two of which it rained all day. This gives an area of 5.3 square miles surveyed each working day. The length of main river is 52 miles, or 1.7 miles per day. The secondary triangulation stations upon which this survey was based were so far apart, and, on the east side so far back from the river that a tertiary system was carried over the entire reach, except that part between Gray's Point and Commerce, Mo.

HYDROGRAPHY.

Three hundred and eighty-nine cross-sections were sounded and a longitudinal line along the channel. The soundings were located by double sextant angles, the observers being in the sounding cutter and reading angles between signals on shore which had been located by the topographers. Care was taken to get many more soundings on shoal crossings than elsewhere. The deepest water found was opposite Grand Tower, 112 feet, and the shoalest section at Crawford's, above Neely's Landing, where 9 feet was the best water at the time of making the survey. Beaver Dam Rock, opposite Burnham's Island, is nearly in the channel of the river at that point. At low water it projects 3 feet above the surface, and is a dangerous obstacle to navigation a large part of the year. It could easily be blasted out, being probably a large detached bowlder.

LEVELS.

On the lower reach a continuous line of levels was run on one bank and river crossings made at each stone line to determine the elevations of the stones furthest back from the river, which had not previously been done. Where these stones had been destroyed new ones were set, and the position and elevation of the top of the stone determined. The elevation of the top of the bank and of the water-surface was determined at each sounding section. All water-gauges and well established high-water marks were connected with.

On the upper reach two lines of levels were run most of the way, one on each bank, checking each other by water-surfaces and by river crossings at each stone line. Seventeen stone lines were established on this reach, the positions and elevations of the tops of the stones being well determined. Bench-marks were also made of triangulation stations, and stones set by other parties. All bench-marks depend for their values on precise bench-marks previously established by the Mississippi River Commission, and are referred to the Memphis Datum Plane.

RÉSUMÉ.

Miles of river surveyed	98
Square miles topography	248
Square miles hydrography	54
Square miles total area	302
Number of soundings	21,088
Number of sextant angles	9,961
Number of working days	59

There are yet 25 miles of river to survey to finish the work assigned to the party last year.

Very respectfully, your obedient servant,

C. M. WINCHELL,
Assistant Engineer.

Capt. THOMAS TURTLE,
Secretary Mississippi River Commission.

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Table of bench-marks established, Grand Tower to Buffalo Island.

Designation.	Locality.	Elevation.	Remarks.
		Feet.	
B. M. 22/1	1½ miles above Grand Tower	368. 26	In Illinois.
B. M. 22/2	..... do	373. 64	Do.
B. M. 22/3	.....do	430. 39	In Missouri.
B. M. 21/1	2 miles below Grand Tower	363. 25	In Illinois.
B. M. 21/2	.....do	364. 17	Do.
B. M. 21/3	.....do	360. 65	On Grand Tower Island.
B. M. 20/1	1 mile below mouth of Big Muddy River	357. 63	In Illinois.
B. M. 20/2	.....do	359. 62	Do.
B. M. 20/3	¼ mile below mouth of Apple Creek	372. 74	In Missouri,
B. M. 19/1	¾ mile below Spring Landing, Illinois	357. 20	In Illinois.
B. M. 19/2	.....do	355. 25=stone 360. 34=pipe	Do.
B. M. 19/3	¼ mile below Dog Creek	352. 82	In Missouri.
B. M. 18/1	1½ mile below Neely's Landing	361. 23	In Illinois.
B. M. 18/2	.....do	352. 85=stone 357. 93=pipe	Do.
B. M. 18/3	¼ mile below Indian Creek	362. 99	In Missouri.
B. M. 17/1	Opposite Moccasin Springs Landing	350. 38=stone 355. 48=pipe	In Illinois.
B. M. 17/2	.....do	353. 60	Do.
B. M. 17/3	¼ mile below Moccasin Springs Landing	370. 31	In Missouri.
B. M. 16/1	¾ mile below Bainbridge Landing	344. 92=stone 350. 00=pipe	In Illinois.
B. M. 16/2	.....do	349. 34	Do.
B. M. 16/3	.....do	360. 88	In Missouri.
B. M. 15/1	1 mile above head of Devil's Island.	348. 45=stone 353. 54=pipe	In Illinois.
B. M. 15/2	.....do	352. 04	Do.
B. M. 15/3	1 mile below Poe's Landing	350. 38	In Missouri.
B. M. 15/4	.....do	354. 09=stone 359. 19=pipe	On left bank of Flora Creek.
B. M. 14/1	¼ mile below foot of Devil's Island.	341. 70=stone 346. 80=pipe	In Illinois.
B. M. 14/2	.....do	350. 22	Do.
B. M. 14/3	1 mile above Cape Rock	390 36=stone 395. 44=pipe	In Missouri.
B. M. 13/1	¼ mile below Wahoo, Ill	343. 86=stone 348. 96=pipe	In Illinois.
B. M. 13/2	.....do	345. 26	Do.
B. M. 12/1	3 miles below Cape Girardeau	345. 04=stone 350. 13=pipe	Do.
B. M. 12/2	.....do	344. 05	Do.
B. M. 12/3	.....do	344. 63	On left bank of Cape La Croix Creek.
B. M. 12/4	.....do	342. 03=stone 347. 13=pipe	In Missouri.
B. M. 11/1	Opposite Gray's Point	336. 42=stone 341. 51=pipe	In Illinois.

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Table of bench-marks established, Grand Tower to Buffalo Island—Continued.

Designation.	Locality.	Elevation.	Remarks.
		Feet.	
B. M. $\frac{11}{2}$	....do	340.23	In Illinois.
B. M. $\frac{10}{2}$	½ mile below Thebes	358.27	Do.
B. M. $\frac{10}{3}$	....do	353.00	In Missouri.
B. M. $\frac{9}{2}$	1 mile above Santa Fé	367.30	In Illinois.
B. M. $\frac{9}{3}$	¾ mile above Commerce	350.19=stone 355.27=pipe	In Missouri.
B. M. $\frac{8}{1}$	1½ miles above Atherton Landing	333.17=stene 338.27=pipe	In Illinois.
B. M. $\frac{8}{2}$	....do	340.47	On Burnham Island.
B. M. $\frac{8}{3}$	2½ miles below Commerce	339.19	In Missouri.
B. M. $\frac{8}{4}$	....do	333.67=stone 338.76=pipe	Do.
B. M. $\frac{7}{1}$	1 mile above Commercial Point	338.75=stone 343.85=pipe	In Illinois.
B. M. $\frac{7}{2}$	....do	337.29	Do.
B. M. $\frac{7}{3}$	On Powers Island	Not leveled to	In Missouri.
B. M. $\frac{7}{4}$	....do	do	Do.
B. M. $\frac{6}{3}$	½ mile below Price Landing	Not det'rm'd	Do.
B. M. $\frac{6}{4}$	....do	do	Do.
△ Simpson 249	1½ miles above Grand Tower	350.23	Do.
* Flag 42	1 mile below Big Muddy River	355.14	In Illinois.
* Flag 43	½ mile below Hines Landing	366.64	Just below mouth of Apple Creek.
* Flag 44	150 meters above B. M. $\frac{19}{2}$	355.06	In Illinois.
△ Indian Creek	Back of B. M. $\frac{19}{3}$ on bluff	481.92	In Missouri.
* Flag 45	½ mile below Devil's Tea Table	503.66	Do.
* Flag 49	½ mile below Bainbridge Landing	352.46	Do.
* Flag 50	1 mile below head of Devil's Island	352.05	In Illinois.
* Flag 51	1½ miles below head of Devil's Island	349.74	In Missouri.
* Flag 52	1 mile above foot of Devil's Island	346.91	½ mile above Big Flora Creek.
* Flag 53	On Cape Rock	432.68	In Missouri.
* Flag 54	Opposite Cape Rock	350.30	In Illinois.
△ Cape Girardeau	In upper edge of Cape Girardeau	439.48	In Missouri.
* Flag 55	Opposite Cape Girardeau	346.94	In Illinois.
* Flag 56	3 miles below Cape Girardeau	342.47	On river bank in Missouri
* Flag 57	½ mile south of B. M. $\frac{12}{1}$	344.35	In Illinois.
△ Cape La Croix	On Gray's Point	480.67	In Missouri.
△ Grand Chain	Opposite Thebes on bluff	439.03	Do.
△ Day	1 mile above Thebes	473.67	In Illinois.
△ Hofner	¾ mile above Commerce	516.40	In Missouri.
△ Burnham	On Burnham Island	338.79	In Illinois.
△ Atherton	1 mile back of Atherton Landing	336.75	Do.

*Stone set by triangulation parties.

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C 2.

REPORT OF ASSISTANT ENGINEER J. A. OCKERSON, ON MECHANICAL DEVICE FOR PRINTING TOPOGRAPHICAL SIGNS AND LETTERS ON ORIGINAL MAPS, AND DESCRIPTION OF A NEW FORM OF PROTRACTOR FOR PLOTTING POLAR CO-ORDINATES.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., June 18, 1885.

SIR: I have the honor to submit the following report on a mechanical method of printing conventional signs on original maps:

In my report of last year, an extract from which is published in the Commission Report, 1884, page 41, an account is given of the experiments which resulted in a satisfactory solution of that part of the problem which relates to the production of suitable stamps or types. Since then the details of manipulation have been solved, and printing the conventional signs has taken the place of the former tedious method of hand-work. Thirty charts have been printed so far, and the results justify the statement that the device is satisfactory both as to the quality and quantity of work done.

The device as now used consists of a wooden cylinder 3 inches long and 4 inches in diameter, covered with rubber one-eighth inch thick, and around this is fixed a very thin electrotype shell of the proper sign, and the whole provided with an adjustable handle, which gives it the appearance of a short rolling-pin. (See Figure I, *w–w*., wooden roller, *r–r*, rubber backing for electrotype shell; *s–s*, electrotype shell, about as thick as ordinary letter paper; *h–h* is the adjustable handle, which can be used with different rollers.)

Figure II is the ink roller with its supporting frame.

The rubber backing and the copper shell, which is very thin, gives sufficient elasticity to admit of printing through a stencil, and the cylinder on which they are placed makes it easy to apply sufficient pressure by hand, as there is only one line in contact with the paper at a time. The size of the cylinder adopted was found, after experiments with various sizes, to give the best results for easy manipulation by hand.

Before printing the signs, the maps are all drawn in outline, and the lettering is printed on them, and it becomes necessary to cover such detail as will be interfe d with by the signs. On the solution of this part of the problem the success of the printing process very largely depended, as it must necessarily be quickly and easily done. After much experimenting, with indifferent results, a starch pencil was finally hit upon, which satisfied every requirement. A hard piece of common starch rubbed once over the lettering or other detail will prevent the ink on the sign-roller from adhering, and after the signs are printed the starch can be easily brushed off, leaving the matter clear and sharp.

In using the sign-printing device, the first step is to prepare stencils of the size and shape of the different fields or kinds of vegetation or other matter which it is desired to represent. A thin tracing paper is the best for this purpose, and stencils for an entire sheet should be prepared before beginning the work of printing. The ink should be the best quality of printers' ink that will dry quickly, and it should be evenly distributed on the ink-roller by first rolling it down flat and smooth on a piece of glass by means of a hand-roller, then passing the ink-roller over the glass plate a few times.

To ink the type cylinder the latter is revolved in contact with the ink-roller till it carries sufficient ink.

In order to get a uniform impression it is essential that the table on which the printing is done should be perfectly smooth and true, as a ridge would show itself in a dark streak and a hollow would give a light or possibly no impression.

When everything is ready for printing, the stencil is laid on the map in its proper place, and the type cylinder, properly inked, is rolled slowly over it, sufficient pressure being applied to the handle to give the required impression. The latter will vary with the quality of paper.

It is evident that the stencil will fix the shape of the field, and if the latter is smaller than the surface of the type cylinder, about 3 by 12 inches, it will all be printed at one movement. If the area is too large for the cylinder, the latter must be inked and the rolling process repeated till the required area is covered. The signs which are in straight lines and regular figures, such as cotton, &c., can easily be matched by inspection, as the roller will always run perfectly true if started properly; for the other signs, like woods, sand, &c., it is best to lay a strip of paper so as to come just to the edge of the printed portion, and, covering it, then let the cylinder overlap a little. For sand it is necessary to leave a narrow strip near the water's edge to be put in by hand, as the stamp can only give a flat tint.

A sample of the work done is submitted herewith.

For an antiquarian sheet with the usual amount of work, say 18 by 40 inches, it re-

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quires about two days for one man to prepare the stencils and do the printing. The same work would employ a good draughtsman nearly a month.

The stamp for printing letters and figures, which is mentioned in the Commission Report of 1884, page 40, is a valuable adjunct to the sign-printing device, and a detailed drawing of it is also submitted.

Figure 1 is a front view of the instrument with the type holder (*t*) in place. A section of the latter is shown at (*s*). Figure 2 shows the base. Figure 3, the piston with the type-holder removed, and showing a section (*a*); the spiral spring which lifts it to its proper place after the name has been printed (*b*); the guide slot (*c*) through which the pin (*e*), Figure 1, passes; (*d*) the pin which holds the type holder or figure-disks in place. Figure 4 is the type-holder detached from piston. Figure 5 is a figure-disk, the slots in which are of a size suited to the type used. Figure 6 is the frame which is cast in one piece, and sections are shown in connection with it.

By the use of the two devices described above the work of mapping is very much facilitated. In a large series of maps it also has the advantage of giving uniform results, which cannot be done when the work is performed by many different hands. The maps can be made for about one-third of the cost when made by hand.

Any desired style can be made use of, as the photo-electrotype process admits of producing stamps from the work of the best draughtsmen.

By this process the work of making hydrographic maps, where the depths are shown by different shades of sanding, becomes very simple and quite rapid.

The rapidity with which work can be done would admit of its being used on original-survey plats, thus adding very much to their value by giving more information as to the character of the lands, boundaries of swamps, timber areas, &c.

If desired, the instrument could be made larger by using mechanical appliances to give the necessary pressure; but unless the amount of work to be done is very great, the simple device mentioned will be found preferable.

This process is well suited to work which is to be reduced by the photographic method, or the map may be published directly by the following means: Draw the outlines and print the letters and figures in lithographic ink on suitable paper, and transfer the same to zinc or stone. From this take a light impression, called an offset, which will show in faint lines the outlines of the transferred map. Print on this with lithographic ink the conventional signs, and transfer to the plate which bears the outlines.

From the plate or stone thus prepared any number of copies can be struck off. It would be better to use zinc than stone, as the plates could be filed away and kept as the originals, and if another edition should be required it could be made use of. This method, used in conjunction with the printing device described above, admits of multiplying copies of a map at a minimum cost.

In the case of land-survey plats above noted, if the originals were prepared on zinc as described, copies could be furnished at a small fraction of the cost by the present method, and each copy would have the advantage of being free from errors which are apt to occur in hand-made copies.

As platting of surveys is closely related to the question of mapping, it may be of interest to give a brief description of a protractor that I have designed for doing this work. It is essentially a semicircular protractor, provided with a needle-pointed pivot at its center and having the straight edge graduated so that distances can be measured off each way from the pivot, while the angular deflection is given by the graduated circle, reading from a point marked on the paper.

The details are shown in a drawing submitted herewith. A section of the pivot plate is shown in Fig. II. The bottom of the plate is flush with the bottom of the protractor, and the hole F is at the center, and should be only large enough to admit a fine needle. The screw D has a hole drilled in its axis to admit the needle-point. It is also split, so that when it is screwed down it will clamp the needle firmly. If the latter is broken, it can readily be replaced by a new one.

In addition to the scale on the beveled edge, a diagonal scale is also provided as shown, and we have in one instrument all the requisites for rapid and accurate platting of points located by polar co-ordinates or by intersections.

In using this protractor the needle-point is placed at, say, the first station, and pressed firmly down.

A meridian line is then decided upon, and a point is marked on it at the outer edge of the protractor circle, and this will be the initial point from which the angles will be read. As azimuth is reached from the south around by the west, it is plain that the circle, numbered as shown and revolved about the pivot till the proper reading coincides with the meridian line, will give the direction of the required point along the graduated diameter, while from the latter the distance can be pricked off. A point can be platted in any direction without lifting the protractor from its position.

In going to the second station it is not necessary to draw a meridian line through it. The azimuth between the first and second stakes being known, if the pivot be set at the latter, and the protractor revolved so that the straight edge coincides with the

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line passing through the two stakes, then the point on the circle corresponding to the azimuth of the line will be a point on the meridian line. This point being marked on the paper is the origin for the angles platted from the second station, and it is evident that they will bear the proper relations to the points platted from the first station.

The same kind of pivot attached to a triangular scale will facilitate platting where many measurements are required from the same point in different directions; or it can be used in connection with a paper protractor with the interior portion cut out, the pivot of the scale being at the center.

Both of these instruments have been tried and the results have been very satisfactory. The platting can be done more rapidly than by any method we have heretofore used, and the work is equally accurate. It also does away with the use of cumbersome tools, such as rulers, triangles, &c., which, in field platting especially, are hard to manipulate.

Very respectfully, your obedient servant,

J. A. OCKERSON,
U. S. Assistant Engineer.

Capt. THOMAS TURTLE,
Secretary Mississippi River Commission.

ACCOMPANYING PLATES.

(1) Details of sign-roller and letter-stamp.
(2) Specimens of work done with above.
(3) Drawings of protractor.
(4) Sample of lithograph from printed signs.

C 3.

REPORT OF ASSISTANT ENGINEER L. L. WHEELER UPON REDUCTION OF OBSERVATIONS FOR DETERMINING ELEVATIONS AND SLOPES OF HIGH AND LOW WATER SURFACES OF THE MISSISSIPPI RIVER BETWEEN CAIRO, ILL., AND CARROLLTON, LA.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., June 17, 1885.

CAPTAIN: I have the honor to submit the following report upon the reduction of observations for determining elevations and slopes of high and low water surfaces of the Mississippi River between Cairo, Ill., and Carrollton, La.

This report is accompanied by tables containing the results of the reduction of all data in this office on the subject. The reductions have been made by Mr. T. C. Thomas, except those for the high waters of 1883 and 1884, which have been made by Mr. John Ewens. All elevations in these tables refer to the Cairo Datum Plane, which is a plane 300 feet below the reading 9.16 feet on the Cairo gauge. Memphis Datum Plane, to which topographical elevations are referred, is 13.13 feet above Cairo Datum Plane. The preliminary elevation of Mean Gulf Level at Biloxi, Miss., is 21.26 feet.

The following table gives the elevations of the gauge zeros:

Gauge.	Elevation.	Gauge.	Elevation.
	Feet.		*Feet.*
Cairo, Ill	290. 84	Greenville, Miss	108. 00
Columbus, Ky	229. 14	Lake Providence, La	89. 62
New Madrid, Mo	276. 04	Vicksburg, Miss	66. 04
Cottonwood Point, Mo	250. 62	Saint Joseph, La	52. 74
Fulton, Tenn	228. 55	Natchez, Miss	36. 83
Memphis, Tenn	203. 97	Red River Landing, La	28. 85
Mhoon's Landing, Miss	181. 48	Port Hickey, La	13. 68
Helena, Ark	161. 98	Baton Rouge, La	20. 06
Saint Louis Landing, Ark	141. 27	Plaquemine, La	21. 06
Mouth White River, Ark	128. 73	College Point, La	21. 24
Arkansas City, Ark	116. 85	Carrollton, La	20. 91

The distances given in the tables are in miles from Cairo, Ill., and have been determined from the inch-to-the-mile series of maps published by the Mississippi River

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Fig.I

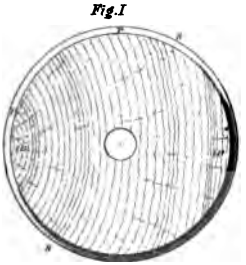
Device for

PRINTING SIGNS

On

Original Maps.

Fig.I



Sign Roller.

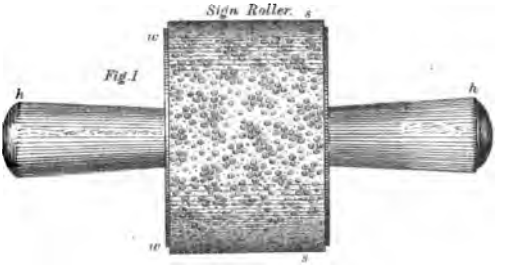
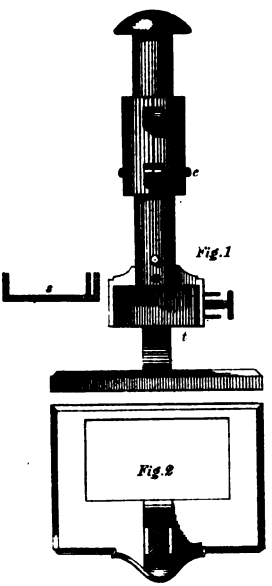


Fig.II

Ink Roller.

Fig.II

Devised by J. A. Dakerson



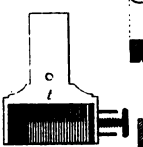


Fig.4

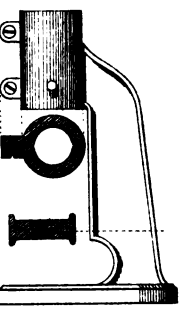


Fig.6

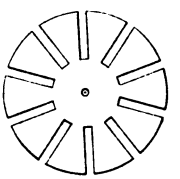


Fig.5

LETTERING DEVICE.

Devised by J. A. Dakerson

Scale.

0 1 2 3 4 5 6 Inch.

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SPECIMENS OF
PRINTED SIGNS
AND LETTERS
For
ORIGINAL MAPS.
SCALE
Lockwood Plantation
Sugar Cane
Cotton
Corn
Sand
Bank Clay
Caving
TALLULA LD'G.
Cultivated
W.H. Andrews
Sand
Sand
Sand
Hackberry
Gum
Oak
Cotton
Corn
Cotton
Corn
Willow
Willow
Willow

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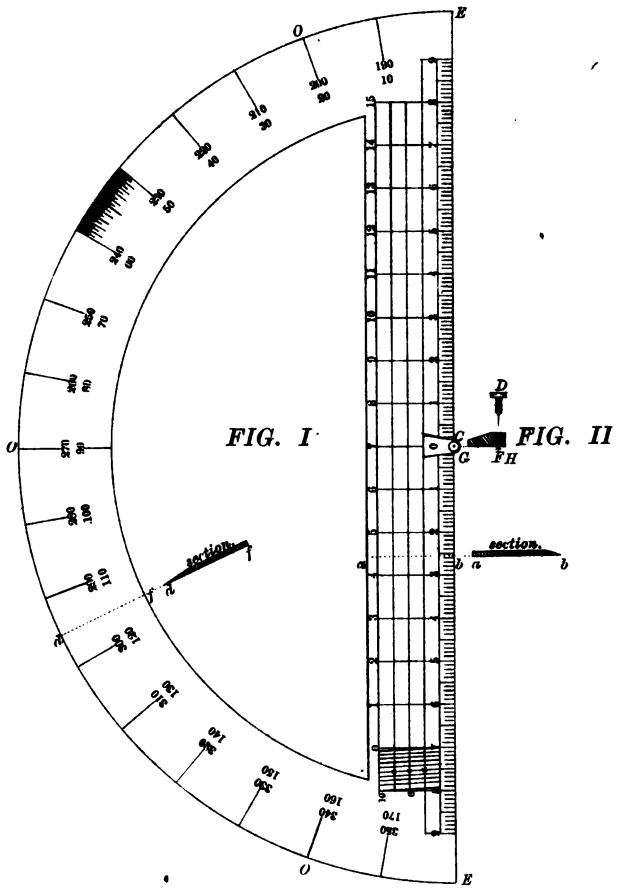

COORDINATE PROTRACTOR.

Revised by J. A. Ockerson
H Ex1 pt2 v2 49 1
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sand
48
50
22 1883.

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Commission. Each point of elevation has been located on these as near as possible, and the nearest tenth of a mile taken as the distance. The name of the nearest place is used to approximately locate the point.

All elevations of water surfaces have been given in the tables, however erroneous they may appear to be when compared with elevations above and below them, but in computing slope all elevations known to be doubtful have been omitted. The doubtful elevations are not in sufficient number to materially detract from the value of the tables, except in those of the low-water slope of 1883, where the number of erroneous elevations is quite large. These, with the large number of points for which there are no elevations at all, very materially diminish the value of the low-water slope for that year. This is the more unfortunate since that is the only low-water slope ever taken over the entire river from Cairo to Carrollton.

HIGH-WATER ELEVATIONS AND SLOPES.

In the following tables are given elevations of high waters for the years 1858, 1862, 1867, 1874, 1876, 1880, 1882, 1883, and 1884, but slopes have been computed for the last four years only, on account of the small number of elevations available for the earlier years. The elevations for high water of 1880 and of previous years, aside from those determined from gauge readings, were determined by a party in charge of Assistant Engineer Arthur Hider. This party commenced work at Cairo November 1, 1880, and reached Carrollton April 9, 1881, in the mean time being engaged on other work as well as determining high-water marks. The work was continued to Buras Settlement, 76 miles below Carrollton, but no lines of levels have been run over this portion of the river, and consequently no elevations are available. The marks were made permanent at the different points, generally by driving a large nail or small spike into a tree at the height of high water, blazing the tree, and cutting in the wood the figures denoting the year. A careful description of each of the marks was made in the note-books.

The elevations for high water of 1882 were determined by parties in charge of Assistant Engineers Hunter Stewart and J. H. Davis. Mr. Stewart commenced work at Cairo August 24, 1882, and continued work to Ashton Landing, La., 520 miles from Cairo, where he was taken sick December 13, 1882, and the work stopped. The work was taken up by Mr. Davis at Vicksburg, January 20, 1883, and completed to Carrollton April 5, 1883. The marks were made permanent in the same manner as those of 1880, and in a great number of cases are at the same localities as those of 1880.

The parties were supplied with postal cards on which were printed forms for recording how much the high water of 1883 was above or below the established marks of 1882. These cards were left with residents in the vicinity of the marks, with a request to make the necessary observation and forward the result to the office of the Commission. These requests were quite largely complied with, and the high water of 1883 has been determined from that of 1882 in this manner, aided by the gauge-readings. The high water of 1884 has been determined in the same manner. The elevations determined in this manner have, in the main, been satisfactory, but are not entitled to the same weight as those determined for the high waters of 1880 and 1882.

The following table contains the elevations of the several high waters at a few common points on the river:

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Elevations of high waters.

Locality.	Distance.	1858.	1862.	1867.	1874.	1876.	1880.	1882.	1883.	1884.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cairo	.....	341.40	342.71	341.81	338.21	337.22	335.44	342.71	343.01	342.63
Columbus	21.2	329.77	330.92	330.44	.....	.....	326.31	331.93	332.42	332.22
Salmon's Landing	33.6	.....	.....	325.56	.....	.....	322.13	326.90	327.23	327.15
Morrisson's Landing	68.9	.....	315.24	.....	.....	.....	310.74	317.29	317.54	317.54
Cottonwood Point	123.3	288.68	288.68	288.09	.....	.....	286.00	288.18	288.47	287.96
Fulton	175.4	.....	.....	.....	.....	.....	262.72	265.22	264.84	264.28
Memphis	230.3	238.13	238.42	238.82	237.97	238.05	237.38	239.12	238.72	238.12
Mhoon's Landing	275.8	.....	.....	.....	.....	.....	217.58	221.28	221.68	220.36
Helena	306.5	206.58	208.37	207.79	207.77	206.82	205.66	209.17	208.88	208.98
Delta	314.4	203.86	.....	.....	203.34	203.10	201.89	204.39	203.97	.....
White River	394.4	.....	.....	175.53	175.33	175.43	175.28	177.13	176.57	176.47
Riverton	399.6	172.34	173.32	171.49	172.45	172.78	172.34	174.48	174.06	173.98
Arkansas City	438.3	.....	.....	.....	.....	.....	161.52	163.45	162.57	162.71
Greenville	478.5	151.00	.....	147.92	148.92	149.28	148.41	149.72	148.40	149.10
Lake Providence	542.3	.....	130.50	128.93	127.00	127.58	126.86	127.94	126.10	128.03
Vicksburg	599.2	112.94	117.14	115.06	111.74	110.94	109.19	114.79	109.84	115.04
Saint Joseph	647.7	.....	.....	.....	.....	.....	94.04	96.87	93.87	97.65
Natchez	700.4	85.08	82.01	84.76	82.44	80.69	79.95	84.43	80.84	84.24
Red River Landing	765.3	.....	.....	70.18	70.85	69.26	67.90	72.35	68.86	70.96
Baton Rouge	833.3	54.57	56.17	.....	56.21	53.46	53.26	56.02	55.15	56.27
Donaldsonville	885.4	.....	48.35	.....	48.29	.....	45.28	47.27	47.27	47.33
Carrollton	957.0	36.01	36.81	.....	36.61	33.61	35.16	35.86	36.31	36.51

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LOW-WATER ELEVATIONS AND SLOPES.

The observations for determining low-water slope of 1880 were made by a party in charge of Assistant Engineer Arthur Hider, between October 8 and 20, 1880, and extend from Cairo to Commerce, Miss., a distance of 270 miles. These observations consisted in leveling from the water-surfaces to temporary bench-marks on the banks about 3 miles apart on the channel side of the river, the bench-marks being subsequently connected with the main line of levels. In all 101 points of elevation were taken, but of these 4 elevations proved erroneous, and for 2 points no elevations were obtained, leaving 95 points of elevation in 270 miles.

In reducing the observations, after the correct elevation of the water-surface at the time of observation has been obtained from the level notes, a correction has been applied to the elevation for oscillation or change of stage. The stage of the river at Cairo, on October 1, was 7.96 feet. The river rose slowly until the 8th when the gauge read 9.40 feet; it then fell slowly until October 15 when the gauge read 7 feet; it rose to 8.35 feet on the 17th, and then slowly fell till the end of the month. At Memphis the river rose slowly to 4.70 feet on the 10th, and then slowly declined. The river was practically stationary at Cairo, October 8; at New Madrid, October 9; at Cottonwood Point, October 10 (a. m.), at Fulton, October 10 (p. m.), and at Memphis October 11; and the stage indicated by the gauge readings on these dates has been assumed as the stage to which the observations should be reduced. The reference stage is really the crest of a small rise, and corresponds to the stage of 9.40 on the Cairo gauge supposed to move down-stream at the rate of 3½ miles per hour.

The difference between the reference stage and the stage at time of observation has been applied as a correction to the observed elevation. The stage at time of observation has been determined by the gauge readings, it being assumed that the changes at points between the gauges were proportional to their distances from the gauges. An interpolation has also been made for the change of stage between the time of observation and the time of gauge reading. The corrections for oscillation are given in the tables, the maximum correction being 1.53 feet.

The observations for determining low-water slope of 1882 were made by a party in charge of Assistant Engineer J. H. Davis, between November 1 and 30, 1882, and extended from Commerce, Miss., to Natchez, Miss., a distance of 431 miles. These observations, like those made in 1880, consisted in leveling from the water-surface to temporary bench-marks on the banks. The points of observation were distributed with reference to the natural features of the river. An effort was made to include either a straight reach or uniform bend between consecutive points. Proximity to some permanent bench-mark was also sought, this being, however, a matter of secondary importance. In all 119 points of observation were taken, but of these 8 were not connected with the main line of levels, leaving 111 points in a distance of 431 miles. There were no elevations found to be erroneous.

During the time these observations were in progress, the stage of river changed very little, there being a slight rise in the lower portion the latter part of the month. The elevations of water-surfaces have been corrected for change of stage, the stage to which they have been reduced corresponding to that of the minimum gauge readings at Mhoon's Landing, Miss., and Natchez, Miss. The minimum gauge reading at Mhoon's Landing was 6.90 feet on October 23, and at Natchez was 9.70 on November 6. This reference stage corresponds to the reading 4.47 fe t on the Memphis gauge. A lower stage was reached at Mhoon's Landing that year, but it had no relation to the stage at which the work was done.

The reference stage at gauges intermediate between Mhoon's Landing and Natchez has been determined in the following manner: It has been assumed that the rate of travel of the minimum stage was uniform from Mhoon's Landing to Natchez, and the date of its arrival at any gauge computed on this assumption. The gauge reading at that time was taken as the stage of reference at each gauge. The dates at all the gauges correspond to the times of minimum readings, except at mouth of White River and Arkansas City, where the readings were affected by a rise out of the White and Arkansas rivers. The difference between the reference stage and the stage at time of observation has been applied as a correction to the observed elevation at any point, the stage at time of observation being determined in the same manner as for the low-water slope of 1880. The maximum correction for oscillation is 4.95 feet.

The observations for determining low-water slope of 1883, were made by a party in charge of Assistant Engineer John Ewens on the steamer Patrol between October 11 and 31, 1883, and extend from Cairo to New Orleans, a distance of 963 miles. Observations were also made between Saint Louis and Cairo, but the temporary bench-marks have not been connected with the main line of levels. The river while this work was in progress was rising throughout its length, the minimum stage having been passed. The minimum gauge reading at Cairo was 4.70 feet on September 30, at Memphis 1.90 feet on October 2, at Vicksburg, 2.90 feet on October 6, and at Carrollton 0.50 foot on October 15.

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The observations, like those of 1880 and 1882, consisted in leveling from the water surface to temporary bench-marks on the banks; but in doing this a long rod graduated to feet and attached to the jack-staff of the steamer was used at nearly all the points. This rod was provided with a special apparatus at the foot for connecting with the water-surface. The points of elevation were chosen at the head and foot of bends, so as to include between them either bends or crossings. The object of this arrangement was to give the slope on the crossings and in the bends separately, but the value of this arrangement is partially destroyed by the number of points for which there are no elevations. In all 279 points were established, but for 86 of these no elevations have been obtained, and for 12 the elevations were erroneous and have been rejected. No work was done by this party along the Plum Point Reach, but bench-marks were established by a topographical party.

The observed elevations of water-surfaces have been reduced to a stage of river corresponding to the minimum gauge reading at Cairo for the year. Were there no tributaries below Cairo this stage in traveling down the river would arrive at each gauge at the time of minimum reading on the gauge, and the time of its occurrence would be indicated by the gauge record. But the larger tributaries affect considerably the readings of gauges near their mouths, and this method is not applicable. The time when the reference stage passed the several gauges has been determined in the following manner: The distance of each gauge from Cairo and the days of the month from September 30 to October 15 were set off along two co-ordinate axes. The whole distance from Cairo to Carrollton was divided into stretches by the terminal gauges and such intermediate gauges as were not liable to be greatly affected by the tributaries. The Greenville and Port Hickey gauges were selected as probably fulfilling the above condition. A line was drawn from the point on the Cairo line representing the time of minimum reading to the point on the Greenville line representing the time of its minimum reading. Assuming the rate of travel of the reference stage to be uniform from Cairo to Greenville, this line will intersect each gauge in the point representing the time at which the reference stage passed that gauge. The other stretches were treated in the same manner. These lines intersect the gauges at or very near the times of minimum readings, the maximum divergence being at Red River Landing where the time of reference stage is two days after the time of minimum reading, and the stage 0.35 foot above the minimum. The rate of travel of reference stage varied considerably, being 119 miles per day from Cairo to Greenville, 47 miles per day from Greenville to Port Hickey, and 40 miles per day from Port Hickey to Carrollton.

The reference stage being determined, the corrections for oscillation have been determined in the same manner as for 1880 and 1882. It will be seen from the tables that the correction for oscillation varies considerably in the length of the river, being 3.15 feet at Cairo, 2.07 feet at Memphis, 6.05 feet at Arkansas City, 4.75 feet at Lake Providence, 5.76 feet at Vicksburg, 5.56 feet at Red River Landing, and 1.30 feet at Carrollton.

Very respectfully, your obedient servant,

L. L. WHEELER,
In Charge Computing Division.

Capt. THOMAS TURTLE,
Secretary Mississippi River Commission.

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Tables of high and low water elevations and slopes, Mississippi River.

HIGH-WATER MARKS OF 1858.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Cairo, Ill	...	.....	341.40	.....	.....	.....	.....	
Widow Mercer's	R.	6.3	338.59	.....	.....	.....	.....	
Columbus, Ky	L.	21.2	329.77	.....	.....	.....	.....	
Above Stewart's	R.	89.0	303.62	.....	.....	.....	.....	
Wilkes, Chute of Islands 16 and 17	R.	117.7	289.52	.....	.....	.....	.....	
Cottonwood Point	R.	123.3	288.68	.....	.....	.....	.....	
Ashport, Tenn	L.	153.3	278.78	.....	.....	.....	.....	
Memphis, Tenn	L.	230.3	238.13	.....	.....	.....	.....	
Helena, Ark	R.	306.5	206.58	.....	.....	.....	.....	
Delta, Miss., opposite	R.	315.5	203.86	.....	.....	.....	.....	
Riverton	L.	399.6	172.34	.....	.....	.....	.....	
Greenville	L.	478.5	151.00	.....	.....	.....	.....	
Vicksburg	L.	599.2	112.94	.....	.....	.....	.....	
Natchez	L.	700.4	85.08	.....	.....	.....	.....	
Baton Rouge	L.	833.3	54.57	.....	.....	.....	.....	
Carrollton	L.	957.0	36.01	.....	.....	.....	May 10	

HIGH-WATER MARKS OF 1862.

Cairo, Ill	...	.....	342.71	.....	.....	.....	.....	
Columbus	L.	21.2	330.92	.....	.....	.....	.....	
Hickman	L.	36.0	325.86	.....	.....	.....	.....	
Morrison's Landing	R.	68.9	315.24	.....	.....	.....	.....	
Brownell's Landing	R.	75.0	312.20	.....	.....	.....	.....	
Gayoso	R.	105.7	297.22	.....	.....	.....	.....	
Wilkes, Chute of Islands 16 and 17	R.	117.7	289.52	.....	.....	.....	.....	
Cottonwood Point	R.	123.3	288.68	.....	.....	.....	.....	
Plum Point	L.	164.2	272.92	.....	.....	.....	.....	
Memphis, Tenn	L.	230.3	238.42	.....	.....	.....	.....	
Harbert's Landing, 1 mile below	L.	293.0	212.61	.....	.....	.....	.....	
Helena, Ark	R.	306.5	208.37	.....	.....	.....	.....	
Riverton (below)	L.	399.6	173.32	.....	.....	.....	.....	
Llewellyn	R.	463.5	154.66	.....	.....	.....	.....	
Lake Providence	R.	542.3	130.50	.....	.....	.....	.....	
Vicksburg	L.	599.2	117.14	.....	.....	.....	April 27	
Opposite Warrenton	R.	606.7	112.28	.....	.....	.....	.....	
Natchez	R.	700.4	82.01	.....	.....	.....	.....	
Baton Rouge	L.	833.3	56.17	.....	.....	.....	.....	
Donaldsonville	R.	885.4	48.35	.....	.....	.....	.....	
Carrollton	L.	957.0	36.81	.....	.....	.....	.....	

HIGH-WATER MARKS OF 1867.

Cairo, Ill	...	.....	341.81	.....	.....	.....	Mar. 21	
Head of Island No. 2	L.	12.0	335.58	.....	.....	.....	.....	? as to year.
Columbus	L.	21.2	330.44	.....	.....	.....	.....	
Salmon's Landing	L.	33.6	325.56	.....	.....	.....	.....	
Hickman	L.	36.0	324.13	.....	.....	.....	.....	
Head of Island No. 8	L.	41.8	321.93	.....	.....	.....	.....	
Lester	L.	53.6	317.46	.....	.....	.....	.....	
Donaldson's Point	R.	59.8	317.28	.....	.....	.....	.....	
Brownell's Landing	R.	75.0	311.54	.....	.....	.....	.....	
Gayoso	R.	105.7	294.48	.....	.....	.....	.....	
Wilkes, Chute of Islands 16 and 17	R.	117.7	289.69	.....	.....	.....	.....	
Above Cottonwood	R.	120.8	288.40	.....	.....	.....	.....	
Cottonwood Point (Garrett's House)	R.	122.4	288.09	.....	.....	.....	.....	
Ward's, Ark	R.	148.2	275.92	.....	.....	.....	.....	

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Table of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1867—Continued.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Above Centennial Cut-off	....	199.6	255.05	.....	.....	.....	.....	
Below ▲ Hearn	L.	211.9	245.19	.....	.....	.....	.....	
Memphis, Tenn	L.	230.3	238.82	.....	.....	.....	.....	
Harbert's Landing	L.	293.0	212.10	.....	.....	.....	.....	
Helena	R.	306.5	207.79	.....	.....	.....	.....	
White River Landing	R.	394.4	175.53	.....	.....	.....	.....	
Riverton	L.	399.6	171.49	.....	.....	.....	.....	
Greenville	L.	478.5	147.92	.....	.....	.....	.....	
Lake Providence	R.	542.3	128.93	.....	.....	.....	.....	
Vicksburg	L.	599.2	115.06	.....	.....	.....	.....	
Opposite Yucatan	R.	629.5	102.44	.....	.....	.....	.....	
Natchez	R.	700.4	84.76	.....	.....	.....	.....	
Fairview	R.	727.6	75.17	.....	.....	.....	.....	
Above Bougere	R.	737.2	76.34	.....	.....	.....	.....	Not well defined.
Red River Landing	R.	765.3	70.18	.....	.....	.....	.....	

HIGH-WATER MARKS OF 1874.

Cairo, Ill	....	.....	338.21	.....	.....	.....	Apr. 26	
Memphis, Tenn	R.	230.3	237.97	.....	.....	.....	May 2	
Helena	R.	306.5	207.77	.....	.....	.....	May 11	
Delta	L.	314.4	203.34	.....	.....	.....	.....	
Friar's Point	L.	319.0	202.19	.....	.....	.....	.....	
Australia Landing	L.	369.7	183.36	.....	.....	.....	.....	
Henrico Landing	R.	383.2	179.11	.....	.....	.....	.....	
White River Landing	R.	394.4	175.33	.....	.....	.....	.....	
Riverton	L.	399.6	172.45	.....	.....	.....	.....	
Catfish Point	L.	423.2	165.71	.....	.....	.....	.....	
Woodstock	L.	464.2	.....	.....	.....	.....	.....	
Greenville	L.	478.5	148.92	.....	.....	.....	.....	
Lake Providence	R.	542.3	127.00	.....	.....	.....	Mar 23	
Duckport	R.	589.7	115.67	.....	.....	.....	.....	
Vicksburg	L.	599.2	111.74	.....	.....	.....	May 2–5	
Natchez	L.	700.4	82.44	.....	.....	.....	Apr. 20	
Fairview	R.	727.6	76.27	.....	.....	.....	.....	
Cerro Gordo	L.	733.9	75.62	.....	.....	.....	.....	
Above Bougere	R.	737.2	76.34	.....	.....	.....	.....	Not well defined.
Red River Landing	R.	765.3	70.85	.....	.....	.....	Apr. 16	
Brunette Point	R.	779.5	67.18	.....	.....	.....	.....	
Waterloo, La	R.	805.2	62.08	.....	.....	.....	.....	
Grossman's Landing	R.	822.1	58.92	.....	.....	.....	.....	
Lobdell's Landing	R.	825.5	56.80	.....	.....	.....	.....	
Baton Rouge	L.	833.3	56.21	.....	.....	.....	Apr. 16	
Missouri Plantation	R.	839.6	55.10	.....	.....	.....	.....	
Hollywood	L.	842.0	54.33	.....	.....	.....	.....	
Forlorn Hope	L.	858.0	53.41	.....	.....	.....	.....	
Point Pleasant	R.	863.4	51.32	.....	.....	.....	.....	
Cora Plantation	R.	868.8	50.31	.....	.....	.....	.....	
Ashland	L.	878.2	49.27	.....	.....	.....	.....	
Donaldsonville	R.	885.4	48.29	.....	.....	.....	.....	
Carrollton	L.	957.0	36.61	.....	.....	.....	Apr. 16	

HIGH-WATER MARKS OF 1876.

Cairo, Ill	....	.....	337.22	.....	.....	.....	Apr. 6	
Below Island No. 29	L.	160.6	270.00	.....	.....	.....	.....	
Above Centennial Cut-off	....	199.6	255.05	.....	.....	.....	.....	
Memphis	L.	230.3	238.05	.....	.....	.....	Apr. 8	
Helena	R.	306.5	206.82	.....	.....	.....	Apr. 18	
Delta	L.	314.4	203.10	.....	.....	.....	.....	
Australia	L.	369.7	183.04	.....	.....	.....	.....	
Henrico Landing	R.	383.2	178.71	.....	.....	.....	.....	

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1876—Continued.

Locality of high-water Mark.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-w	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
White River Landing	R.	394.4	175.43	.....	.....	.....	Apr. 8–15	
Riverton (below)	L.	399.6	172.78	.....	.....	.....	.....	
Niblett's	L.	414.7	168.71	.....	.....	.....	.....	
Catfish Point	L.	423.2	166.42	.....	.....	.....	.....	
Woodstock	L.	464.2	.....	.....	.....	.....	.....	
Greenville	L.	478.5	149.28	.....	.....	.....	.....	
Lake Providence	R.	542.3	127.58	.....	.....	.....	Apr. 14	
Vicksburg	L.	599.2	110.94	.....	.....	.....	May 10	
Natchez	L.	700.4	80.69	.....	.....	.....	May 15	
Red River Landing	R.	765.3	69.26	...	.....	.....	May 15	
Baton Rouge	L.	833.3	53.46	.....	.....	.....	May 15	
Carrollton	L.	957.0	33.61	.....	.....	.....	May 11	

HIGH-WATER MARKS OF 1880.

Cairo, Ill	....	....	335.44	.....	.....	.....	Mar. 22	
Columbus	L.	21.2	326.31	9.13	21.2	0.431	.....	
Salmon's Landing	L.	33.6	322.13	4.18	12.4	.337	.....	
James Bayou	R.	44.5	318.65	3.48	10.9	.319	.....	
Donaldson's Point	R.	56.4	314.45	4.20	11.9	.353	.....	
Bryant's Point	R.	62.8	313.79	0.66	6.4	.103	.....	
Morrison's Landing	R.	68.9	310.74	3.05	6.1	.500	Mar. 24	
Point Pleasant	R.	80.0	306.70	4.04	11.1	.364	.....	
Tiptonville	L.	85.3	302.53	4.17	5.3	.787	.....	
Stewart's Landing	R.	89.6	300.92	1.61	4.3	.374	.....	
Above ▲ River-Bed	L.	97.2	300.06	0.86	7.6	.113	.....	
▲ Perkins	L.	111.4	289.12	10.94	14.2	.770	.....	
▲ Bell's Point	L.	120.1	286.40	2.72	8.7	.313	.....	
Cottonwood Point	R.	123.3	286.00	0.40	3.2	.125	Mar. 24–6	
Wright's Point	R.	133.7	279.31	6.69	10.4	.643	.....	
Rucker's Point	L.	139.7	279.28	.....	.....	.....	.....	
Mean	....	140.0	279.26	0.05	6.3	.008	.....	
Buckner's Landing	R.	140.2	279.25	.....	.....	.....	.....	
▲ Sheep	L.	143.0	274.90	.....	.....	.....	.....	? As to year.
▲ K. C. B	L.	144.8	.....	.....	.....	.....	.....	
Ashport, Tenn	L.	153.3	270.98	8.28	13.3	.623	.....	
Elmot	R.	159.2	268.48	2.50	5.9	.424	.....	
Osceola Landing	R.	165.7	267.32	1.16	6.5	.178	.....	
Fort Pillow	L.	171.6	265.63	1.69	5.9	.286	.....	
Fulton, Tenn	L.	175.4	262.72	2.91	3.8	.766	Mar. 26	
Randolph	L.	182.6	259.15	3.57	7.2	.496	.....	
Above Mound City	R.	224.7	240.36	18.79	42.1	.446	.....	
Memphis, Tenn	L.	230.3	237.38	2.98	5.6	.532	Mar. 24–9	
Star Landing	L.	258.2	225.98	11.40	27.9	.409	.....	
Bennett's Landing	L.	263.0	223.92	2.06	4.8	.429	.....	
Mhoon's Landing	L.	275.9	217.58	6.34	12.9	.491	.....	
O. K. Landing	L.	289.4	211.12	6.46	13.5	.478	.....	
Glendale	L.	306.8	205.66	5.46	17.4	.314	.....	
Above Delta	L.	311.5	203.28	2.38	4.7	.506	.....	
Delta	L.	314.4	201.89	1.39	2.9	.479	.....	
Friar's Point	L.	319.0	200.53	1.36	4.6	.296	.....	
Archie Lucas Place	L.	321.5	199.17	1.36	2.5	.544	.....	
Opposite Miller's Point	R.	324.0	198.38	0.79	2.5	.316	.....	
Opposite Hulberton	R.	333.4	194.13	4.25	9.4	.452	.....	
Foot Island No. 64	R.	242.5	191.22	2.91	9.1	.320	.....	
Saint Louis Landing	R.	349.5	186.06	5.16	7.0	.737	.....	
Malone's Landing	L.	356.2	186.00	0.06	6.7	.009	.....	
Dr. Anderson's Landing	L.	359.0	....	.....	.....	.....	.....	
▲ Pushmataha	L.	359.1	184.41	1.59	2.9	.548	.....	
Australia	L.	369.7	182.90	1.51	10.6	.142	.....	
Concordia	L.	378.0	180.12	2.78	8.3	.335	.....	
Terrene	L.	394.2	177.03	.....	.....	.....	.....	
White River Landing	R.	394.4	175.28	4.84	16.4	.295	Mar. 23–5	
Riverton	L.	399.6	172.34	2.94	5.2	.565	.....	
Niblett's	L.	414.3	168.91	3.43	14.7	.233	.....	
Bolivar	L.	416.8	168.17	0.74	2.5	.296	.....	

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1880—Continued.

Locality of high-water mark.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Buckridge	L.	418.2	167.36	0.81	1.4	.579		
Catfish Point	L.	423.2	166.27	1.09	5.0	.218		
New Hope	R.	423.2						
Eutaw, Miss	L.	433.2	163.11	3 16	10.0	.316		
Shelby's Landing	L.	438.8	161.60					
Mean		438.3	161.52	1.59	5.1	.312		
Arkansas City	R.	438.3	161.45				Mar. 26-7	
Offutts	L.	444.6	158.98	2.54	6.3	.403		
Moss Lake	L.	456.2	156.80	2.18	11.6	.188		
Woodstock	L.	464.2						
Greenville	L.	478.5	148.41	8.39	22.3	.376		
Leland (Craigs)	R.	483.5	147.53	0.88	5.0	.176		
Warfield Point	L.	484.1	146.98	0.55	0.6	.917		
Vaucluse	R.	486.7	146.63	0.35	2.6	.135		
Refuge	L.	491.1	145.09	1.54	4.4	.350	Mar. 24-7	
Glenora	L.	498.5	141.94	3.15	7.4	.426		
Mathews Bend	R.	507.0	139.19	2.75	8.5	.323		
Leota	L.	511.7	136.66	2.53	4.7	.538		
Carolina Landing	L.	516.8	135.14	1.52	5.1	.298		
Duncansby	L.	529.0	130.98	4.16	12.2	.341		
Vista Landing	R.	535.5	129.11	1.87	6.5	.288		
Ben Lomond	L.	542.3	126.70					
Mean		542.3	126.86	2.25	6.8	.330		
Lake Providence	R.	542.3	127.02				Apr. 3	
De Sona Plantation	R	544.0	126.22	0.64	1.7	.377		
Point Lookout	R.	553.2	122.78	3.44	9.2	.374		
Concord	R.	555.0						
Wilton Landing	R.	560.0	121.59	1.19	6.8	.175		
Below Pecan Grove	R.	567.5						
Henderson	R.	573.5						
Omega	R.	578.1	113.98	7.61	18.1	.420		
Milliken's Bend	R.	581.0						
Duckport	R.	589.7	111.62	2.36	11.6	.203		
Vicksburg	L.	599.2	109.19	2.43	9.5	.256	Apr. 8-9	
Delta	R.	601.0	108.14	1.05	1.8	.583		
Opposite Warrenton	R.	606.7	106.20	1.94	5.7	.340		
Moore's Landing	R.	614.8	103.67	2.53	8.1	.312		
Kellogg's Landing	R.	616.5						
Point Pleasant	R.	622.2	102.68	0.99	7.4	.133		
Opposite Yucatan	R.	629.5	98.98	3.70	7.3	.507		
Hardscrabble	R.	639.7	95.36	3 62	10.2	.355		
Saint Joseph, La	R.	647.7	94.04	1.32	8.0	.165	Apr.16-17	
Rodney	L.	651.1	92.78	1.26	3.4	.371		
Beeler's Landing	R.	655.2	91.12	1.66	4.1	.405		
Waterproof	R.	663.6	89.57	1.55	7.8	.199		
Durango	R.	668.4	87.65	1.92	5.4	.356		
Covington	R.	679.8	86.01	1.64	11.4	.144		
Gibson's Landing	R.	683.4	84.54	1.47	3.6	.408		
Good Hope	R.	691.0	83.13	1.41	7.6	.186		
Natchez	L.	700.4	80.34				Apr. 16	
Mean		700.6	79.95	3.18	9.6	.331		
Vidalia	R.	700.8	79.56					
Moro Plantation	R.	709.0	78.45					Water stain on tree.
Morville	R.	710.0	78.52	1.43	9.4	.152		Nail in tree.
Green's Landing	R.	720.6	75.50	3.02	10.6	.285		
Fairview	R.	727.6	74.17	1.33	7.0	.190		
Cerro Gordo	L.	733.9						
Above Bougere	R.	737.2	72.76	1.41	9.6	.147		
Grand Cut-off Plantation	R.	744.5	71.29	1.47	7.3	.201		
Port Adams	L.	754.8						
Point Breeze	R.	756.9	69.53	1.76	12 4	.142		
Red River Landing	R.	765.3	67.90	1.63	8.4	.193	Apr. 22	
Leatherman's Landing	R.	772.9	64.29	3.61	7.6	.475		
Brunette Point	R.	779.5	64.78	0.51	6.6	.077		
New Texas	R.	786.3	62.94	1.84	6.8	.271		
Opposite Morganza Crevasse	L.	790.8	61.62	1.32	4.5	.293		
Pointe Coupeé	R.	795.1	60.65	0.97	4.3	.226		
Waterloo	R.	805.2	58.95	1.70	10.1	.168		

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1880—Continued.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Opposite Port Hickey	R.	810.0	57.76	1.19	4.8	.248	Apr. 22	
Foot of Prophet Island	R.	819.3	55.61	2.15	9.3	.231		
Grossman's Landing	R.	822.1	55.55	0.06	2.8	.021		
Lobdell's Landing	R.	825.5	54.68	0.87	3.4	.256		
Port Allen	L.	832.5	53.38	1.30	7.0	.186		
Baton Rouge	L.	833.3	53.26	0.12	0.8	.150	Apr. 22–24	
Missouri Plantation	R.	839.6	52.43	0.83	6.3	.132		
Hollywood	L.	842.0	51.41	1.02	2.4	.425		
Plaquemine	R.	853.5	50.06	1.35	11.5	.117	Apr. 23–25	
Brode's Store	R.	854.7	49.59	0.47	1.2	.392		
Forlorn Hope, P. O	L.	858.0	48.74	0.85	3.3	.258		
Point Pleasant	R.	863.4	48.40	0.34	5.4	.063		
Bayou Goula	R.	866.1	47.98	0.42	2.7	.156		
Cora Plantation	R.	868.8	47.66	0.32	2.7	.119		
Ashland Plantation	L.	878.2	46.17	1.49	9.4	.158		
Evan Hall	R.							
Donaldsonville	R.	885.4	45.28	0.89	7.2	.124		
Point Houmas	R.	889.7						
Opposite White Hall	R.	893.8						
College Point	L.	903.0	42.59	2.69	17.6	.153	Apr. 21	
Belmont	L.	906.8	42.36	0.23	3.8	.061		
Armand	R.	609.1						
Mount Airy	L.	915.0	40.78	1.58	9.2	.193		
Terre Haute	L.	920.5	39.67	1.11	5.5	.202		
La Place	L.	925.5						
Bonnet Carré Crevasse	L.	927.5						
Destrahan	L.	939.0	36.64	3.03	18.5	.164		
Almadia	L.	943.5						
Fairview	L.	944.5						
Carrollton	L.	957 0	35.16	1.48	18.0	.082	Apr. 23	

HIGH-WATER MARKS OF 1882.

Cairo, Ill			342.71				Feb. 26	
Dr. Hale's	R.	5.8	340.17	2.54	5.8	.438		
Widow Mercer's	R.	6.3	339.94	0.23	0.5	.460		
O'Brien's	R.	14.0	336.12	3.82	7.7	.496		
Columbus	L.	21.2	331.94				Feb. 26	
Mean		21.2	331.93	4.19	7.2	.582		
Belmont	R.	21.2	331.92					
Beckwith's	R.	28.3	328.74	3.19	7.1	.449		
Salmon's Landing	L.	33.6	326.90	1.84	5.3	.347		
Hickman	L.	36.0	326.06	0.84	2.4	.350		
Saint James' Bayou	R.	44.5	323.69	2.37	8.5	.279		
Newsom's Landing	R.	49.3	321.39	2.30	4.8	.479		
Lester's Landing	L.	53.7	320.75	0.64	4.4	.145		
Morrisson's	R.	68.9	317.29	3.46	15.2	.228	Feb. 27	† as to date.
Toney Landing	R.	75.0	313.04	4.25	6.1	.697		
Point Pleasant	R.	79.5	311.55	1.49	4.5	.331		
Tiptonville	L.	85.4	308.31	3.24	5.9	.549		
Stewart's Landing	R.	89.6	305.55	2.76	4.2	.657		
Gayoso	R.	105.7	297.18	8.37	16.1	.520		
Ferris Landing	R.	108.8	294.72	2.46	3.1	.794		
Below Caruthersville	R.	111.0	293.77	0.95	2.2	.432		
Chute of Island 16 and 17.	R.	115.4	291.45	2.32	4.4	.527		
Wilke's, Chute of Island 16 and 17	R.	117.7	290.52	0.93	2.3	.404		
Garrett's, Cottonwood Point	R.	122.4	288.18	2.34	4.7	.498	Feb. 28	
Mrs. Hickman	R.	131.4	286.61	1.57	9.0	.174		
Buckner's Landing	R.	140.0	281.74	4.87	8.6	.566		
Ward's, Ark	R.	148.2	277.42	4.33	8.2	.527		
Ashport, Tenn	L.	153.8			5.1			
Duncan's store*	L.	153.6	274.52	2.90	0.3	.537		

*High-water marks from Duncan's Store to mouth of Cold Creek furnished by Assistant W. H. Powless.

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Table of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1882—Continued.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Johnson's Landing	L.	156.7	272.91	1.61	8.1	.519		
		157.3	272.62	0.29	0.6	.483		
		158.7	271.80	0.82	1.4	.586		
		160.0	271.44	0.36	1.3	.277		
		161.2	271.01	0.43	1.2	.358		
Plum Point	L.	163.3	270.24	0.77	2.1	.367		
		164.3	269.69	0.55	1.0	.550		
Yankee Bar	L.	165.3	269.44	0.25	1.0	.250		
		167.3	267.92	1.52	2.0	.760		
Mouth of Cold Creek	L.	172.0	266.91	1.01	4.7	.215		
Fulton, Tenn	L.	175.4	265.22	1.69	3.4	.497	Mar. 1	
Mouth of Hatchee River	L.	179.7	263.69	1.53	4.3	.356		
Randolph	L.	182.6	261.57	2.12	2.9	.731		
Preston's Landing	R.	186.7	258.12	3.45	4.1	.841		
Pecan Point	R.	195.8	253.97	4.15	9.1	.456		
Thomas's Landing	L.	200.9	252.94	1.03	5.1	.202		
Randolph Point	L.	210.4	247.86	5.08	9.5	.535		
Redman's Point	R.	220.5	243.50	4.36	10.1	.432		
Memphis, Tenn	L.	230.3	239.12	4.38	9.8	.447	Mar. 6	
Lake's Landing	R.	236.6	237.44	1.68	6.3	.267		
Merryweather's	R.	239.6	235.36	2.08	3.0	.693		
Ensley's, Tenn	L.							
Hampton's Landing	R.	241.8			2.2			
Harris's Landing	R.	244.5	284.18	1.18	2.7	.241		
Scanlan's Landing	R.	247.5	232.90	1.28	3.0	.427		
Norfolk Landing	L.	254.3	228.35	4.55	6.8	.669		
Bennett's Landing	L.	263.0	224.36	3.99	8.7	.459		
Commerce	L.	269.8	222.57	1.79	6.8	.263		
Mhoon's Landing	L.	275.8	221.28	1.29	6.0	.215	Mar. 8	
Bordeaux Point Landing	L.	278.7	219.94	1.34	2.9	.462		
O. K. Landing	L.	289.4	215.79	4.15	10.7	.388		
Harbert's Landing	L.	293.0	214.18	1.61	3.6	.447		
Trotter's Landing	L.	303.5	210.44	3.74	10.5	.356		
Helena, Ark	R.	306.5	209.17	1.27	3.0	.423	Mar. 9	
William's Landing	R.	309.7			3.2			
Delta, Miss	L.	314.4	204.39	4.78	4.7	.605		
Westover, Ark	R.	318.8	202.60	1.79	4.4	.407		
Miller's Point	L.	324.7	199.75	2.85	5.9	.483		
Jackson Point Landing	L.	344.2	191.04	8.71	19.5	.447		
Ludlow's Landing	R.	346.4	189.92	1.12	2.2	.509		
Saint Louis Landing	R.	349.5	189.01	0.91	3.1	.294		
Sunflower Landing	L.	352.7	188.59	0.42	3.2	.131		
Malone's Landing	L.	356.2	187.18	1.41	3.5	.403		
Pushmataha	L.	359.1	186.82	0.36	2.9	.124		
Knowlton's Landing	L.	366.1	185.19	1.63	7.0	.233		
Australia	L.	369.7	184.16	1.03	3.6	.286		
Laconia, Ark	R.	373.3	182.74	1.42	3.6	.394		
Concordia	L.	378.0	182.06	0.68	4.7	.145		
Henrico Landing	R.	383.2	180.61	1.45	5.2	.279		
Mouth of White River	R.	394.4	177.13	3.48	11.2	.311	Feb. 28	
Rosedale	L.	398.2	175.07	2.06	3.8	.542		
Miles' or Riverton	L.	399.6	174.48	0.59	1.4	.421		
Prentiss	L.	403.6	174.34	0.14	4.0	.035		Stone seems to have been disturbed.
Niblett's Landing	L.	414.3	171.06	3.28	10.7	.307		
Bolivar, Miss	L.	416.8	170.15	0.91	2.5	.364		
Cat Fish Point	L.	423.2	168.25	1.90	6.4	.297		
Eutaw	L.	433.2	166.81	2.44	10.0	.244		(f) as to elevation.
Mound Place	L.	435.3	165.02	0.79	2.1	.376		
Arkansas City	R.	438.3	163.45	1.57	3.0	.523	Feb. 28	
Port Anderson	L.	443.2	160.60	2.85	4.9	.582		
Offutt's Landing	L.	444.6	160.48	0.12	1.4	.114		
Gaines' Landing	R.	449.5	159.77	0.71	4.9	.137		
Point Comfort	R.	454.5	156.88	2.89	5.0	.578		
Llewellyn	R.	463.5	155.19	1.69	9.0	.188		
Luna Landing	R.	467.4	154.35	0.84	3.9	.215		
Greenville	L.	478.5	149.72	4.63	11.1	.417	Feb. 27	
Craig's Landing	R.	483.5	148.55	1.17	5.0	.234		
Warfield	L.	484.1	148.20	0.35	0.6	.583		

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Tables of high and low-water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1882—Continued.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Refuge	L.	491.1	145.77	2.43	7.0	.347	.....	
Glenora	L.	498.5	144.13	1.64	7.4	.222	.....	
Lake Washington	L.	504.7	141.65	2.48	6.2	.400	.....	Indefinite.
Ross Landing	R.	506.4	140.23	1.42	1.7	.835	.....	
Carolina Landing	L.	516.8	136.23	4.00	10.4	.385	.....	
Ashton Landing	R.	520.5	134.92	1.31	3.7	.354	.....	
Lake Providence	R.	542.3	127.94	6.98	21.8	.320	.....	
Point Lookout	R.	553.2	124.65	3.29	10.9	.302	.....	
Near Edgewood	R.	563.5	118.98	5.67	10.3	.551	.....	
Vicksburg	L.	599.2	114.79	4.19	35.7	.117	Mar. 20	U. S gauge.
Delta	R.	601.0	114.13	0.66	1.8	.367	.....	
Opposite Warrenton	R.	606.7	111.88	.....	.....	.....	.....	
Mean	....	606.7	111.83	2.30	5.7	.403	.....	
Warrenton	L.	606.7	111.78	.....	.....	.....	.....	
Diamond Point	L.	611.1	110.04	1.79	4.4	.407	.....	
Moore's Landing	R.	614.8	109.23	0.81	3.7	.219	.....	
New Town	L.	618.5	107.86	1.37	3.7	.370	.....	
Point Pleasant Landing	R.	622.2	106.88	0.98	3.7	.265	.....	
Bland's Store	R.	623.2	106.28	0.60	1.0	.600	.....	
Brooks' Landing	L.	626.0	103.80	2.48	2.8	.886	.....	
Hard Times Landing	R.	632.1	102.56	1.24	6.1	.203	.....	(f)
Hard Scrabble	R.	639.7	98.39	4.17	7.6	.549	.....	
Bondurant	R.	641.8	97.17	1.22	2.1	.581	.....	
Saint Joseph	R.	647.7	96.87	0.30	5.9	.051	Mar. 20	
Rodney	L.	651.1	96.24	0.63	3.4	.185	.....	
Beeler's Landing	R.	655.2	94.35	1.89	4.1	.461	.....	
Kemps' Landing	R.	659.8	93.40	0.95	4.6	.207	.....	
Waterproof	R.	663.0	93.25	0.15	3.2	.047	.....	
Durango Landing	R.	668.4	91.61	1.64	5.4	.304	.....	
Cypress Grove	L.	668.9	91.57	0.04	0.5	.080	.....	
L'Argent Landing	R.	679.3	90.52	.....	.....	.....	.....	(f)
Covington Landing	R.	679.8	89.43	2.14	10.9	.196	.....	This point gives a better slope.
Gibson's Landing	R.	683.4	88.63	0.80	3.6	.222	.....	
Good Hope	R.	691.0	87.16	1.47	7.6	.193	.....	
Stacy Plantation	R.	696.6	85.65	1.51	5.6	.270	.....	
Natchez	L.	699.5	84.43	1.22	2.9	.421	Mar. 28	
Vidalia	R.	700.8	84.13	0.30	1.3	.231	.....	
White Hall Plantation	R.	703.7	84.05	0.08	2.9	.028	.....	
Foot of Natchez Island	R.	707.2	83.31	0.74	3.5	.211	.....	
Moro Plantation	R.	709.0	82.67	0.64	1.8	.356	.....	
Moroville	R.	710.0	82.65	0.02	1.0	.020	.....	
Green's Landing	R.	720.6	80.66	1.99	10.6	.188	.....	Indefinite.
Ashley Landing	R.	724.0	80.65	0.01	3.4	.003	.....	
Palmetto Landing	L.	727.3	79.59	1.07	3.3	.324	.....	
Fairview Landing	R.	727.6	79.51	0.08	0.3	.267	.....	
Roseland Plantation	R.	729.0	79.37	0.14	1.4	.100	.....	
Cerro Gordo Landing	L.	733.9	78.56	0.81	4.9	.165	.....	
G. W. Walton's Plantation	R.	737.2	78.25	0.31	3.3	.094	.....	
Bougere Landing	R.	737.9	78.12	0.13	0.7	.186	.....	
Union Point Landing	R.	742.0	77.24	0.88	4.1	.215	.....	
Kienstras Landing	L.	742.8	76.74	0.50	0.8	.625	.....	
Grand Cut-off Plantation	R.	744.5	76.53	0.21	1.7	.124	.....	
Lochleven Landing	L.	746.8	76.27	.....	.....	.....	.....	
Mean	....	747.0	76.28	0.25	2.5	.100	.....	
Black Hawk Landing	R.	747.2	76.29	.....	.....	.....	.....	
Ballamagan Plantation	R.	749.7	76.09	0.19	2.7	.070	.....	
Stamp's Landing	L.	750.8	75.89	0.20	1.1	.182	.....	
Bartlett Plantation	L.	752.4	75.24	0.65	1.6	.406	.....	
Fort Adams	L.	754.8	74.97	0.27	2.4	.113	.....	
Point Breeze Plantation	R.	756.9	75.05	.....	.....	.....	.....	Not reliable.
Langside Plantation	L.	758.0	73.82	1.15	3.2	.359	.....	
Above Mouth Red River	R.	759.5	73.20	0.62	1.5	.413	.....	
Trager's Landing	L.	761.3	73.08	0.12	1.8	.067	.....	
Carr's Point Landing	R.	762.8	72.63	0.45	1.5	.300	.....	
Red River Landing	R.	765.3	72.35	0.28	2.5	.112	Mar. 27	U. S. gauge.
Smith's Landing	R.	767.0	71.66	0.69	1.7	.406	.....	
Cat Fish Point	R.	769.7	70.26	1.40	2.7	.519	.....	
Tunica Landing	L.	772.7	69.54	0.72	3.0	.240	.....	
Brunette Point	R.	780.8	67.53	2.01	8.1	.248	.....	
Sebastopol, ½ mile above	L.	781.7	67.40	0.13	0.9	.144	.....	

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Tables of high and low-water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1882—Continued.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Opposite Sebastopol	R.	782.2	66.98	0.42	0.5	.840		
Raccourci Landing	R.	784.8	66.95	0.03	2.6	.012		
New Texas	R.	786.3	66.79	0.16	1.5	.107		
Above Morganza	R.	789.3	65.50	1.29	3.0	.430		
Opp. Morganza Crevasse	L.	790.8	64.88	0.62	1.5	.413		
Stewart's Place	R.	793.3	64.83	0.05	2.5	.020		
Above Coupée P. O	R.	794.9	65.00					
Mean		795.2	64.52	0.31	1.9	.163		
Above Bayou Sara	L.	795.5	64.04					
Bayou Sara	L.	799.5	63.28	1.24	4.3	.288		
Below Bayou Sara	R.	801.0	62.76	0.52	1.5	.347		
Waterloo	R.	805.2	62.36	0.40	4.2	.095		
Hermitage	R.	807.8	61.64	0.72	2.6	.277		
Port Hickey	L.	810.0	(†) 61.58	0.06	2.2	.027	Mar. 28	(†) U. S. gauge.
Above Kelson's Store	R.	811.2	60.33	1.25	1.2	1.042		
Kelson's Store	R.	813.6	60.41					
Mean		813.9	60.18	0.15	2.7	.056		
Opposite Prophet Isl'd	L.	814.2	59.96					
Lower Springfield Landing	L.	818.9	59.30	0.88	5.0	.176		
Grossman's Landing	R.	822.1	58.74	0.56	3.2	.175		
Thomas Point	L.	823.9	58.90					Not well located.
J. L. Lobdell's Landing	R.	825.5	58.08	0.66	3.4	.194		
Port Allen Landing	R.	832.5	56.40	1.68	7.0	.240		
Baton Rouge	L.	833.3	56.02	0.38	0.8	.475	Mar. 26	U. S. gauge.
Arlington Plantation	L.	837.3	55.34	0.68	4.0	.170		
Duncan's Point	L.	837.8	55.34	0.00	0.5	.000		† as to year.
Missouri Plantation	R.	839.6	55.12	0.22	1.8	.122		
Hollywood Plantation	L.	842.0	54.02	1.10	2.4	.458		
Above Manchac	L.	843.4	53.91	0.11	1.4	.079		
Woodstock Plantation	L.	844.6	53.89	0.02	1.2	.017		
Auger's Plantation	L.	845.7	53.48	0.41	1.1	.373		
Above Plaquemine	R.	850.7	52.66	0.82	5.0	.164		
Plaquemine	R.	853.5	52.36	0.30	2.8	.107	Mar. 21–27	U. S. gauge.
Brode's Store	R.	854.7	52.16	0.20	1.2	.167		
Opposite Forlorn Hope	R.	858.0	52.50					Made by a planter.
Forlorn Hope	L.	858.0	52.10	0.06	3.3	.018		Made by a U. S. assistant engineer and connected directly with a P. B. M.
Avery Plantation	L.	860.1	50.78					
Point Pleasant	R.	863.4	50.93	1.17	5.4	.217		A better slope.
Ophelia Landing	L.	864.9	50.65	0.28	1.5	.187		
Opposite Bayou Goula	L.	865.7	50.31					
Mean		865.9	50.37	0.28	1.0	.280		
Bayou Goula	R.	866.1	50.43					
Cora Plantation	R.	868.8	49.75	0.62	2.9	.214		
Opposite Belle Grove	L.	869.8	49.47	0.28	1.0	.280		
Southwood	L.	874.4	48.98	0.49	4.6	.107		
Ashland Plantation	L.	878.2	48.61	0.37	3.8	.097		
Donaldsonville	R.	885.4	47.27	1.34	7.2	.186		
Hagan Plantation	L.	892.0	46.21	1.06	6.6	.161		
Colombia Plantation	L.	897.7	45.28	0.93	5.7	.163		
Convent Post-Office	L.	901.3	44.68	0.60	3.6	.167		
College Point	L.	903.0	44.44	0.24	1.7	.141	Mar. 26	U. S. gauge.
Belmont Plantation	L.	906.8	44.15	0.29	3.8	.076		
Hester (Belle Aliance Plantation.)	L.	907.8	43.61	0.54	1.0	.540		
Mount Airy Plantation	L.	915.0	42.96	0.65	7.2	.090		
Terre Haute	L.	920.5	41.62	1.34	5.5	.244		
Bonnet Carré Post-Office	L.	926.5	41.54	0.08	6.0	.013		
La Place Plantation	L.							
Man's Plantation	L.	930.5	39.41	2.13	4.0	.532		
Prospect Plantation	L.	934.5	39.22	0.19	4.0	.048		
Destrahan Plantation	L.	939.0	38.15	1.07	4.5	.238		
Longue's Plantation	L.	943.0	37.86	0.29	4.0	.072		
Kennerville	L.	947.0	37.36	0.50	4.0	.125		
Twelve Mile Point	L.	951.1	36.24	1.12	4.1	.273		
Carrollton	L.	957.0	35.86	0.38	5.9	.064	Mar. 27	U. S. gauge.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1883.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per miles.	Date high water.		Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*				
Cairo, Ill	...	.....	343.010	.....	.....	.....	Feb.	27	U. S. gauge.
Mercer's, Mo	R.	6.3	340.265	2.745	6.3	0.430	Feb.	27	
O'Brien's, Mo	R.	14.0	336.700	3.565	7.7	.460	Feb.	27	
Belmont, Mo	R.	21.3	332.418	4.282	7.3	.586	Feb.	25	
Salmon's, Ky	L.	33.0	327.230	5.188	11.7	.443	Feb.	28	
Hickman, Ky	L.	36.0	326.356	0.874	3.0	.289	Feb.	26	
Saint James Bayou, Mo	R.	44.5	324.148	2.208	8.5	.250	Feb.	27	
Morrison's, Mo	R.	69.0	317.542	6.606	24.5	.260	Feb.	28	U. S. gauge.
Toney's Landing, Mo	R.	75.0	313.608	3.934	6.0	.655	Feb.	28	
Point Pleasant, Mo	R.	79.5	310.877	2.731	4.5	.610	Feb.	28	
Cottonwood Point, Mo	R.	123.3	288.474	22.403	43.8	.511	Feb.	28	
Buckner's, Ark	R.	140.0	281.903	6.571	16.7	.393	Feb.	26	
Fulton, Tenn	L.	175.4	264.838	17.065	35.4	.480	Mar.	2	U. S. gauge.
Randolph, Tenn	L.	182.6	261.011	3.827	7.2	.530	Mar.	2	
Pecan Point, Ark	R.	196.0	253.196	7.815	13.4	.580	Mar.	1	
Thomas' Landing, Tenn	L.	201.2	252.942	0.254	5.2	.048	Mar.	1	
Redman's Point, Ark	R.	220.5	243.627	9.315	19.3	.480	Mar.	4	
Memphis, Tenn	L.	230.0	238.720	4.907	9.5	.510	Mar.	6	U. S gauge.
Norfolk Landing, Miss	L.	254.3	227.767	10.953	24.3	.450	Mar.	9	
Commerce, Miss	L.	269.8	222.153	5.614	15.5	.360	Mar.	8	
Mhoon's Landing, Miss	L.	275.8	221.680	0.473	6.0	.780	Mar.	8	U. S. gauge.
Bordeaux Point Landing	L.	278.5	219.273	2.407	2.7	.891	Mar.	10	
Helena, Ark	R.	306.5	208.880	10.393	28.0	.371	Mar.	8	U. S. gauge.
Delta, Miss	L.	314.5	203.974	4.906	8.0	.613	Mar.	6	
Saint Louis Landing, Ark	R.	349.5	189.054	14.920	35.0	.426	Mar.	10	U. S. gauge.
Sunflower, Miss	L.	352.7	188.880	0.174	3.2	.054	Mar.	10	
Australia, Miss	L.	369.7	184.119	4.761	17.0	.280	Mar.	10	
Laconia, Ark	R.	373.3	182.569	1.550	3.6	.440	Mar.	10	
Mouth of White Riv'r, Ark	R.	393.2	176.570	5.999	19.9	.301	Feb.	26	U. S. gauge.
Miles' (Riverton, Miss.)	L.	399.0	174.060	2.510	5.8	.432	Mar.	11	
Niblett's, Miss	L.	414.7	170.031	4.029	15.7	.256	Mar.	15	
Bolivar, Miss	L.	416.8	169.50	0.530	2.1	.252	Mar.	10	
Cat-Fish Point, Miss	L.	423.2	167.34	2.161	6.4	.337	Mar.	11	
Eutaw, Miss	L.	433.2	164.119	3.221	10.0	0.322	Mar.	8	
Mound Place, Miss	L.	435.5	163.944	1.750	2.3	.761	Mar.	11	
Arkansas City, Ark	R.	438.3	162.570	1.374	2.8	.491	Mar.	11	U. S. gauge.
Llewellyn, Ark	R.	463.0	155.421	7.149	24.7	.290	Mar.	10	
Luna Landing, Ark	R.	467.4	153.861	1.560	4.4	.300	Mar.	12	
Greenville, Miss	L.	478.5	148.400	5.461	11.1	.490	Mar.	10	U. S. gauge.
Leland's, Ark	R.	483.5	148.147	0.253	5.0	.051	Mar.	11	
Refuge, Miss	L	491.1	145.979	2.168	7.6	.280	Mar.	16	
Glenora, Miss	L.	499.5	143.993	1.986	8.4	.230	Mar.	25	
Ross Landing, Ark	R.	506.5	139.416	4.577	7.0	.653	Mar.	10	
Lake Providence, La	R.	542.3	126.100	13.316	35.8	.371	Mar.	11	U. S. gauge.
Delta, La	R.	597.6	109.961	16.139	55.3	.291	Apr.	5	
Vicksburg, Miss	L.	599.3	109.840	0.121	1.7	.071	Apr.	5	U. S. gauge.
Saint Joseph, La	R.	648.3	93.871	15.969	49.0	.325	Apr.	7	U. S. gauge.
Kemp's Landing, La	R.	659.7	90.401	3.470	11.4	.304	Apr.	7	
Durango Landing, La	R.	668.4	88.735	1.666	8.7	.191	Apr.	7	
Gibson's Landing, La	R	683.5	84.630	4.105	15.1	.271	Apr.	7	
Good Hope Landing, La	R.	691.0	84.160	0.470	7.5	.063	Apr.	10	
Natchez, Miss	L.	700.3	80.840	3.320	9.3	.356	Apr.	10	U. S. gauge.
Moro Plant, La	R.	709.0	80.285	0.555	8.7	.064	Apr.	9	
Grand Cut-off, La	R.	745.0	72.279	8.006	36.0	.222	Apr.	9	
Black Hawk, La	R.	747.2	72.042	0.237	2.2	.108	Apr.	10	
Stamp's Landing, Miss	L.	750.8	72.043	—0.001	3.6	.000	Apr.	9	
Fort Adams, Miss	L.	755.1	71.000	1.043	4.3	.242	Apr.	10	
Red River Landing, La	R.	765.3	68.860	2.140	10.2	.209	Apr.	9	U. S. gauge.
Smith's Landing, La	R.	767.0	68.664	0.196	1.7	.115			
Brunette Point, La	R.	780.8	64.798	3.866	13.8	.280	Apr.	10	
New Texas, La	R.	785.8	64.459	0.339	5.0	.068	Apr.	10	
Opposite Morganza, La	L.	789.7	63.382	1.077	3.9	.276	Apr.	10	
Bayou Sara, La	L.	799.5	61.783	2.599	10.8	.240	Apr.	9	
Port Hickey, La	L.	810.0	61.150	0.633	10.5	.060	Apr.	9	U. S. gauge.
Kelson's Store, La	R.	813.6	59.328	1.822	3.6	.506	Apr.	9	
Grossman's Landing, La	R.	822.6	57.493	1.835	9.0	0.203	Apr.	2	
Port Allen, La	R.	832.5	55.489	2.004	9.9	.020	Apr.	9	
Baton Rouge, La	L.	833.3	55.154	0.335	0.8	.410	Apr.	9	U. S. gauge.
Missouri Plant., La	R.	839.6	54.418	0.736	6.3	.120	Apr.	9	

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Table of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1883—Continued.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Woodstock Plant., La	R.	844.0	53.311	1.107	4.4	.250	Apr. 9	
Plaquemine, La	R.	853.5	51.960	1.351	9.5	.140	Apr. 9	U. S. gauge.
Brode's Landing, La	R.	854.8	51.823	0.137	1.3	.105	Apr. 9	
Forlorn Hope, La	L.	858.0	51.561	0.262	3.2	.080	Apr. 9	
Bayou Goula, La	R.	866.1	50.181	1.380	8.1	.170	Apr. 9	
Cora Plant., La	R.	868.7	49.339	0.842	2.6	.320	Apr. 10	
Ashland, La	L.	878.2	48.525	0.814	9.5	.080	Apr. 9	
Donaldsonville, La	R.	885.4	47.078	1.447	7.2	.200	Apr. 9	
Colombia Landing, La	L.	897.0	45.758	1.320	11.6	.110	Apr. 9	
College Point., La	L.	903.0	44.640	1.118	6.0	.186	Apr. 8	U. S. gauge.
Belmont Plant., La	L.	906.0	43.876	0.764	3.0	.254	Apr. 9	
Mount Airy Plant., La	L.	915.0	43.541	0.335	9.0	.037	Apr. 10	
Prospect Plant., La	L.	935.0	39 965	3.576	20.0	.178	Apr. 9	
Kennerville, La	L.	947.0	37.683	2.282	12.0	.190	Apr. 9	
Carrollton, La	L.	957.0	36 310	1.373	10.0	.137	Apr. 7	U. S. gauge.

HIGH-WATER MARKS OF 1884.

Cairo, Ill	....	0.0	342.630	.....	.....	.....	Feb. 22	U. S. gauge.
Belmont, Mo	R.	21.3	332.220	10.410	21.3	.488	Feb. 23	U. S. gauge.
Salmon's, Ky	L.	33.6	327.147	5.073	12.3	.412	Mar. 9	
Hickman, Ky	L.	36.0	326.306	0.841	2.4	.350	Mar. 3	
Saint James Bayou, Mo	R.	44.5	324.020	2.286	8.5	.268	Mar. 1	
Watson's Point, Ky	L.	67.8	317.680	6.340	23.3	.272	Feb. 24	
Morrison's Mo	R.	69.0	317.540	0.140	1.2	.116	Feb. 24	U. S. gauge.
Lazelle's Landing, Mo	R.	82.4	309.210	8.330	13.4	.621	Feb. 24	
Bass Landing, Tenn:	L.	95.1	302.555	6.655	12.7	.524	Feb. 24	
Hathaway's, Tenn	L.	102.9	297.240	5.315	7.8	.677	Feb. 24	
Gayoso, Mo	R.	105.7	295.650	1.590	2.8	.578	Feb. 24	
Cottonwood Point, Mo	R.	123.3	287.960	7.690	17.6	.436	Feb. 23	
Fulton, Tenn	L.	175.4	264.282	23.678	52.1	.454	Feb. 25	U. S. gauge.
Thomas Landing, Tenn	L.	200.9	252.630	11.652	25.5	.457	Feb. 28	
Memphis, Tenn	L.	230.3	238.120	14.510	29.4	.494	Mar. 1	U. S. gauge.
Mhoon's Landing, Miss	L.	275.0	220.360	17.760	44.7	.397	Mar. 5	U. S. gauge.
Helena, Ark	R.	306.5	208.980	11.380	31.5	.361	Mar. 6	U. S. gauge.
Friar's Point, Miss	L	319.0	202.299	6.681	12.5	.534	Mar. ?	
Miller's Point, Miss	L.	324.7	199.501	2.798	5.7	.491		
Saint Louis Landing, Ark	R.	349.5	189.475	10.026	24.8	.404	Mar. 6	U. S. gauge.
Sunflower, Miss	L.	352.7	188.830	0.645	3.2	.202	Mar. 6	
Beith's Landing, Ark	R.	366.1	185.686	3.144	13.4	.234	Mar. ?	
Australia, Miss	L.	369.7	184.493	1.193	3.6	.331	Mar. ?	
Cumbyville (Mo. White River)	R.	394.4	176.470	8.023	24.7	.325	Mar. 7	U. S. gauge.
Riverton, Miss	L.	399.6	173.980	2.490	5.2	.479	Mar. 9	
Niblett's, Miss	L.	414.7	170.401	3.579	15.1	.237		
Bolivar, Miss	L.	416.8	169.693	0.708	2.1	.337	Mar. 8	
Cat-Fish Point, Miss	L.	423.2	167.589	2.104	6.4	.328	Mar. 8	
Arkansas City, Ark	R.	438.3	162.710	4.879	15.1	.323	Mar. 7	U. S. gauge.
Gaine's Landing, Ark	R.	449.5	159.690	3.020	11.2	.270	Mar. 8	
Greenville, Miss	L.	478.5	149.100	10.590	29.0	.365	Mar. 8	U. S. gauge.
Leland's, Ark	R.	483.5	148.052	1.048	5.0	.208	Mar. 11	
Refuge, Miss	L.	491.1	144.771	3.281	7.6	.431	Mar. 15	
Lake Providence, La	R.	542.3	128.030	16.741	51.2	.327	Mar. 23	U. S. gauge.
Delta, La	R.	597.6	115.454	12.576	55.3	.227	Mar. 23	
Vicksburg, Miss	L.	599.3	115.040	0.414	1.7	.243	Mar. 25	U. S. gauge.
Moore's Landing, La	R.	614.8	111.604	3.436	15.5	.221	.....	
Newtown, Miss	L.	618.5	108.029	3.575	3.7	.966	Mar. 25	
Point Pleasant, La	R.	622.2	107.047	0.982	3.7	.265	Mar. 30	
Hard Times, La	R.	632.1	103.059	3.988	9.9	.402	Mar. 24	
Saint Joseph, La	R.	648.3	97.650	5.409	16.2	.333	Mar. 20	U. S. gauge.
Rodney, Miss	L.	651.1	96.961	0.689	2.8	.244	Mar. 23	
L'Argent, La	R.	679.3	91.272	5.689	28.2	.202	Mar. 23	
Natchez, Miss	L.	700.4	84.240	7.032	21.1	.333	Mar. 24	U. S. gauge.
Bougere's Landing, La	R.	737.9	77.672	6.568	37.5	.175	.....	
Black Hawk, La	R.	747.2	73.801	3.871	9.3	.416	Mar. 29	
Red River Landing, La	R.	765.3	70.960	2.841	18.1	.156	Mar. 29	U. S. gauge.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

HIGH-WATER MARKS OF 1884—Continued.

Locality of high-water marks.	Banks.	Distance from Cairo.	Elevation, Cairo datum.	Fall between high-water marks.	Distance between high-water marks.	Slope, feet per mile.	Date high water.	Remarks.
		Miles.	*Feet.*	*Feet.*	*Miles.*			
Port Hickey, La	L.	810.0	61.100	9.860	44.7	.221	Mar. 29	U. S. gauge.
Baton Rouge, La	L.	833.3	56.270	4.830	23.3	.207	Mar. 24	U. S. gauge.
Missouri Plantation, La	R.	839.6	55.544	0.726	6.3	.115	Mar. 25	
Woodstock Plantation, La	R.	844.6	54.224	1.320	5.0	.264	Mar. 24	
Plaquemine, La	R.	853.5	52.660	1.564	8.9	.176	Mar. 24	U. S. gauge.
Brode's Landing, La	R.	854.8	52.488	0.172	1.3	.132	Mar. 24	
Bayou Goula, La	R.	866.1	50.930	1.558	11.3	.137	Mar. 24	
Ashland, La	L.	878.2	49.355	1.575	12.1	.130	Mar. 24	
Donaldsonville, La	R.	885.4	47.327	2.028	7.2	.281	Mar. 23	
Colombia Landing, La	L.	897.7	45.654	1.673	12.3	.136	Mar. 24	
College Point, La	L.	903.0	45.290	0.364	5.3	.069	Mar. 24	U. S. gauge.
Belmont Plantation, La	L.	906.8	44.646	0.644	3.8	.169	Mar. 1–10	
Mount Airy Plantation, La	L.	915.0	43.085	1.561	8.2	.190	Mar. 24	
Carrollton, La	L.	957.0	36.510	6.575	42.0	.156	Mar. 18	U. S. gauge.

LOW-WATER SLOPE OF 1880.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
1	Cairo, Ill			300.20		300.20			*	Oct. 8	2 p. m.
2	Three States Ferry	L.	2.4	299.62	+ .02	299.64	0.56	2.4	0.233		4 p. m.
3	Island, No. 1	L.	6.0	298.96	.07	299.03	.61	3.6	.169	Oct. 9	7 a. m.
4	△ Beckwith	R.	8.6	298.13	.07	298.20	.83	2.6	.319	Oct.	9 a. m.
5	△ Davidson	L.	9.1	297.65	.08	297.73	.47	0.5	.940		9 a. m.
6	△ Island No. 2	L.	12.4	297.39	.08	297.47	.26	3.3	.079		11 a. m.
7	△ Tarr	R.	15.1	296.96	.07	297.03	.44	2.7	.163		12 m.
8	△ Cannon	R.	18.0	296.32	.08	296.40	.63	2.9	.217		2 p. m.
9	Columbus, Ky	L.	21.2	295.90	.06	295.96	.44	3.2	*.138		3 p. m.
10	△ Thorn	L.	23.0	295.09	.04	295.13	.83	1.8	.461		4 p. m.
11	△ Muscavally	L.	25.2	293.90	.04	293.94	1.19	2.2	.541		5 p. m.
12	△ Wiggins	L.	27.5	292.43	.02	292.45	1.49	2.3	.648	Oct. 10	8 a. m.
13	△ Ferris Landing	R.	28.9	291.78	.03	291.81	.64	1.4	.457		9 a. m.
14	△ Parker	R.	32.0	290.51	.04	290.55	1.26	3.1	.406		10 a. m.
15	Above Salmon's	L.	33.7	289.90	.05	289.95	.60	1.7	.353		11 a. m.
16	△ Hickman	L.	36.2	289.50	.05	289.55	.40	2.5	.160		11 a. m.
17	△ Kaiser	L.	38.7	289.39	.06	289.45	.10	2.5	.040		1 p. m.
18	△ French's Point	L.	41.6	288.55	.10	288.65	.80	2.9	.276		3 p. m.
19	△ St. James	R.	44.5	287.72	.10	287.82	.83	2.9	.286		3 p. m.
20	Below St. James Bayou	R.	46.8	286.81	.11	286.92	.90	2.3	.391		4 p. m.
21	△ Mitcham	L.	50.0	286.66	.13	286.79	.13	3.2	.041		5 p. m.
22	Above △ Lester	L.	53.6	285.88	.27	286.15	.64	3.6	.178	Oct. 11	8 a. m.
23	△ Birdsall	R.	55.6	284.85	.27	285.12	1.03	2.0	.515		9 a. m.
24	Below △ Tennessee	L.	59.5	284.52	.25	284.77	.35	3.9	.090		2 p. m.
25	△ Bryant's Point	R.	62.9	282.86	.28	283.14	1.63	3.4	0.479	Oct. 11	4 p. m.
26	Below △ Everett	L.	66.1	281.35	.28	281.63	1.51	3.2	.472		6 p. m.
27	Morrison's Landing	R.	68.9	280.65	.25	280.90	.73	2.8	*.261		4 p. m.
28	Below New Madrid	R.	71.1	279.01	.46	279.47	1.43	2.2	.650	Oct. 12	8 a. m.
29	△ Bob Watson	L.	74.7	277.92	.45	278.37	1.10	3.6	.306		8 a. m.
30	Below △ Compromise	L.	77.3	276.02	.47	276.49	1.88	2.6	.723		9 a. m.
31	△ Point Pleasant	R.	80.0	274.00	.46	274.46	2.03	2.7	.752		10 a. m.
32	Above △ Gold	R.	82.7	272.97	.48	273.45	1.01	2.7	.374		12 m.
33	Tiptonville	L.	85.3	270.52	.47	270.99	2.46	2.6	.946		12 m.

* United States gauge.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW-WATER SLOPE OF 1880—Continued.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
34	Below △ Stewart	R.	90.1	268.67	+.77	269.44	1.55	4.8	.323	Oct. 13	12 m.
35	Near △ Solitude	R.	93.3	267.74	.50	268.24	1.20	3.2	.375	Oct. 12	4 p. m.
36	Below △ Bass	L.	96.8	265.60	.52	266.12	2.12	3.5	.606		6 p. m.
37	△ Dr. Smith	L.	99.6	263.29	.78	264.07	2.05	2.8	.732	Oct. 13	10 a. m.
38	Above Gayoso	L.	102.5	264.64	.82	265.46	.....	2.9	(†)		11 a. m.
39	Gayoso	R.	105.6	262.63	.86	263.49	.58	3.1	.097		2 p. m.
40	△ Warden	R.	107.2	260.59	1.16	261.75	.....	1.6	...	Oct. 14	10 a. m.
41	Near △ Caruthersville	R.	110.3	261.28	1.17	262.45	1.04	3.1	‡.226		10 a. m.
42	△ Linwood	L.	113.8	259.16	1.24	260.40	2.05	3.5	.586		12 m.
43	Booth's Point	L.	117.5	257.19	1.26	258.45	1.95	3.7	.527		12 m.
44	△ Bell's Point	L.	120.3	254.86	1.28	256.14	2.31	2.8	.825		3 p. m.
45	Cottonwood Point	R.	123.1	254.47	1.36	255.83	.31	2.8	*.111		3 p. m.
46	Lintdale	R.	125.3	253.50	1.32	254.82	1.01	2.2	.459		5 p. m.
47	△ Arkansas	R.	128.9	254.64	1.30	255.94	.....	3.6	(§)		5 p. m.
48	△ Mrs. H	R.	131.3	252.29	1.27	253.56	1.26	2.4	.210		6 p. m.
49	Wright's Point	R.	133.7	248.96	1.53	250.49	3.07	2.4	1.279	Oct. 15	8 a. m.
50	△ Hale's Point	L.	136.0	248.52	1.51	250.03	.46	2.3	.200		8 a. m.
51	Near △ Nebraska	L.	138.3	248.16	1.49	249.65	.38	2.3	.165		9 a. m.
52	△ Buckner	R.	140.2	247.72	1.47	249.19	.46	1.9	.242		9 a. m.
53	Above △ Barfield	R.	141.7	247.37	1.45	248.82	.37	1.5	.247		10 a. m.
54	△ K. C. B	L.	144.8	.....	1.43	.....	.....	3.1	(‖)		12 m.
55	Near △ Forked Deer	L.	146.4	246.26	1.41	247.67	1.15	1.6	¶.244		12 m.
56	Below △ Bowen	R.	149.3	247.63	1.39	249.02	.....	2.9	.....		2 p. m.
57	△ Daniel's Point	R.	152.0	245.19	1.42	246.61	1.06	2.7	.189		3 p. m.
58	Ashport, Tenn	L.	153.3	244.77	1.36	246.13	.48	1.3	.369		2 p. m.
59	Johnson's Landing	L.	156.2	244.19	1.35	245.54	.59	2.9	.203		4 p. m.
60	Below △ Fletcher	R.	157.5	242.96	1.33	244.29	1.25	1.3	.961		4 p. m.
61	Two miles below △ Fletcher	R.	159.7	241.55	1.33	242.88	1.41	2.2	.641		5 p. m.
	△ Elmot	R.	161.4	241.05	1.41	242.46	.42	1.7	.247	Oct. 16	7 a. m.
62	Plum Point	L.	164.2	238.74	1.41	240.15	2.31	2.8	.825		8 a. m.
63	Below Osceola	R.	165.7	238.71	1.41	240.12	.03	1.5	.020		9 a. m.
64	Below Bullerton T. H	R.	170.5	234.76	1.41	236.17	3.95	4.8	.823		10 a. m.
65	Fulton	L.	175.4	234.32	1.41	235.73	.44	4.9	*.090		11 a. m.
66	△ Lee	L.	176.9	233.60	1.45	235.05	.68	1.5	.453		4 p. m.
67	Near foot of Island No. 34	R.	179.8	231.60	1.45	233.05	2.00	2.9	.690		4 p. m.
68	Below △ Pierce	R.	182.5	228.70	1.45	230.15	.....	.....	.....		5 p. m.
69	Mean	..	182.6	.....	.....	230.32	2.73	2.8	.975		.....
70	Randolph	L.	182.7	229.05	1.45	230.50	.....	.....	.....		6 p. m.
71	Richardson's Landing	L.	185.8	228.78	1.41	230.19	.13	3.2	.041	Oct. 17	8 a. m.
72	Near △ Lanier	R.	188.4	227.51	1.41	228.92	1.27	2.6	.488		9 a. m.
73	△ Golden Lake	R.	191.5	225.12	1.41	226.53	2.39	3.1	0.771	Oct. 17	9 a. m.
74	△ Powers	R.	193.7	223.96	1.42	225.38	1.15	2.2	.523		10 a. m.
75	△ Pecan Point	R.	195.8	223.36	1.41	224.77	.61	2.1	.290		11 a. m.
76	△ Wright	L.	198.0	222.57	1.41	223.98	.79	2.2	.359		12 m.
77	P. B. M. No. 52	L.	201.2	221.03	1.41	222.44	1.54	3.2	.481		4 p. m.
78	Head of Centennial Cut-off	L.	203.3	220.82	1.38	222.20	.24	2.1	.114		5 p. m.
79	△ Bateman	L.	207.5	217.77	1.42	219.19	3.01	4.2	**.717	Oct. 18	8 a. m.
80	Head of Fogleman's Chute	R.	207.9	217.53	1.41	218.94	3.26	4.6	.709		8 a. m.
							[.69	3.6	††.192]		
81	△ Hearn	L.	211.1	217.08	1.42	218.50	0.44	3.2	.138		9 a. m.
82	△ Bradley's Landing	R.	214.7	214.24	1.42	215.66	2.84	3.6	.789		10 a. m.
83	△ Ferguson	R.	217.9	212.40	1.42	213.82	1.84	3.2	.575		11 a. m.
84	△ Walt	R.	220.3	210.29	1.41	211.70	2.12	2.4	.883		12 m.
85	△ Morrisey	L.	224.1	209.17	1.41	210.58	1.12	3.8	.295		2 p. m.
86	Below Mound City	R.	226.9	208.14	1.41	209.55	1.03	2.8	.368		3 p. m.
87	Memphis	L.	230.3	207.96	1.41	209.37	.18	3.4	*.053		5 p. m.
88	3 miles below Memphis	R.	235.0	207.31	1.12	208.43	.94	4.7	.200	Oct. 19	12 m.
89	Opposite Foot Vice-President's Island	R.	236.7	205.90	1.15	207.05	1.38	1.7	.812		12 m.
90	Dismal Point	R.	239.2	203.45	1.16	204.61	2.44	2.5	.976		12 m.
91	Below △ Ensley	L.	241.9	201.48	1.16	202.64	1.97	2.7	.730		2 p. m.
92	△ Watson	L.	.....	.....	1.18	.....	.....	.....	.....		3 p. m.

* United States gauge.
† As to elevation of reference B. M.
‡ B. M. connected with in 1883-'84.
§ Reference B. M., a stake marking △ Arkansas.
‖ Elevation of reference B. M. undetermined.
¶ W. S. referred to a P. B. M.
** In Bateman's Bend.
†† Slope through Bateman's Bend, between stations 78 and 81.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW WATER SLOPE OF 1880—Continued.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
93	Above Scanlan's	L.	246.8	198.79	+1.17	199.96	2.68	4.9	.547		4 p. m.
94	Below Scanlan's	R.	249.3	197.47	1.18	198.65	1.31	2.5	.524		5 p. m.
95	Above Pickering's	R.	251.6	197.15	1.06	198.21	.44	2.3	.191	Oct. 20	8 a. m.
96	Norfolk Landing	L.	253.8	196.46	1.05	197.51	.70	2.2	.318		8 a. m.
97	Star Landing	L.	258.2	195.35	1.05	196.40	1.11	4.4	.252		9 a. m.
98	Above Bennett's	R.	261.4	194.69	1.06	195.75	.65	3.2	.203		10 a. m.
99	Bennett's Landing	L.	263.0	193.46	1.06	194.52	1.23	1.6	.769		11 a. m.
100	Excelsior Landing	R.	266.5	192.44	1.07	193.51	1.01	3.5	.289		12 m.
101	Commerce	L.	269.8	190.91	1.08	191.99	1.52	3.3	.461		1 p. m.

LOW-WATER SLOPE OF 1882.

1	Commerce Landing	L.	270.0	191.16	—0.72	190.44				Nov. 1	4 p. m.
2	Campbell's Landing	R.	272.4	189.98	.78	189.20	1.24	2.4	0.517	Nov. 2	8 a. m.
3	Mhoon's Landing	L.	276.0	189.39	.80	188.59	.61	3.6	.169		11 a. m.
4	Bordeaux Landing	L.	278.5	187.55	.80	186.75	1.84	2.5	.736		2 p. m.
5	Bordeaux Chute	L.	283.0	184.83	.81	184.02	2.73	4.5	.607		4 p. m.
6	O. K. Landing	L.	290.1	180.26	.82	179.44	4.58	7.1	.645	Nov. 3	9 a. m.
7	Harbert's Landing	L.	293.4	180.04	.81	179.23	.21	3.3	.064		12 m.
8	Dr. Horner's	R.	299.3		.79						4 p. m.
9	Helena Island	L.	302.2		.80					Nov. 4	6 a. m.
10	Trotter's Landing	L.	303.5	172.61	.80	171.81	7.42	10.1	.735		9 a. m.
11	Helena, Ark	R.	306.2	172.53	.79	171.74	.07	2.7	*.026		6 a. m.
12	Williams Landing	R.	311.0	171.17	.74	170.43	1.31	4.8	.273		5 p. m.
13	Delta Landing	L.	314.5	168.69	.72	167.97	2.46	3.5	.703	Nov. 5	9 a. m.
14	Craig's Landing	R.	317.0	166.94	.69	166.25	1.72	2.5	.688		12 m.
15	Archie Lucas Place	L.	320.8	166.73	.65	166.08	.17	3.8	.044		2 p. m.
16	Opposite Miller's Point	R.	324.2	166.58	.62	165.96	.12	3.4	.035		4 p. m.
17	Allison's Landing	R.	328.1		.64					Nov. 6	8 a. m.
18	Opposite Island No. 62	L.	330.2		.61						10 a. m.
19	Modoc Landing	R.	335.0	162.55	.53	162.02	3.94	10.8	.365		12 m.
20	Robson's Landing	L.	340.0	160.59	.46	160.13	1.89	5.0	.378		3 p. m.
21	Jackson's Point	L.	342.6		.42						4 p. m.
22	Offutt's or Ludlow's	R.	347.1	159.41	.37	159.04	1.09	7.1	.154	Nov. 7	8 a. m.
23	Saint Louis Landing	R.	349.4	158.34	.33	158.01	1.03	2.3	.448		12 m.
24	Sunflower Landing	L.	352.5	156.55	.27	156.28	1.73	3.1	.558		12 m.
25	Malone's Landing	L.	356.2	155.91	.22	155.69	.59	3.7	0.159	Nov. 7	2 p. m.
26	Pushmataha	L.	359.3	155.49	.20	155.29	.40	3.1	.129		4 p. m.
27	Foot of Island No. 68	R.	364.1	151.86	.22	151.64	3.65	4.8	.760	Nov. 8	7 a. m.
28	Beith's Landing	R.	366.3	151.74	.21	151.53	.11	2.2	.050		10 a. m.
29	Australia	R.	369.6	149.99	.20	149.79	1.74	3.3	.527		11 a. m.
30	Laconia	R.	373.4	148.87	.19	148.68	1.11	3.8	.292		1 p. m.
31	Head of Island No. 71	R.	376.2		.18						3 p. m.
32	Maysonia Landing	L.	377.8	147.23	.18	147.05	1.63	4.4	.370		4 p. m.
33	△Antler's	R.	381.6	146.61	.23	146.38	.67	3.8	.176	Nov. 9	8 a. m.
34	Caswell Place	R.	386.7	142.63	.22	142.41	3.97	5.1	.779		10 a. m.
35	McGehee's Landing	L.	391.1	140.58	.21	140.37	2.04	4.4	.464		12 m.
36	Terrene	L.	394.3	140.41							4 p. m.
&	Mean		394.4	140.44	.20	140.24	.13	3.3	.039		
37	Cumbyville	R.	394.4	140.47						Nov. 10	7 a. m.
38	Rosedale	L.	398.2	139.74	.20	139.54	.70	3.8	.184		10 a. m.
39	Below Napoleon	R.	403.1	138.72	.20	138.52	1.02	4.9	.208		12 m.
40	Below Prentiss	L.	404.2	138.59	.20	138.39	.13	1.1	.118		1 p. m.
41	Below Ozark Island	R.	409.6		.20			5.4			3 p. m.
42	Caulk's Landing	R.	413.0	136.53	.20	136.33	2.06	8.8	.234		5 p. m.
43	Bolivar	L.	417.3	132.97	.20	132.77	3.56	4.3	.828	Nov. 11	7 a. m.
44	Cat Fish Point	L.	423.2	131.23	.20	131.03	1.74	5.9	.295		9 a. m.
45	Cypress Creek	R.	426.5	130.12	.20	129.92	1.11	3.3	.336		12 m.
46	Chicot City	R.	431.8	129.50	.21	129.29	.63	5.3	.119		1 p. m.
47	Mound Place	L.	435.7	127.38	.22	127.16	2.13	3.9	.546		3 p. m.
48	Wilkerson's Landing	L.	436.8	126.32	.23	126.09	1.07	1.1	.973		5 p. m.
49	Arkansas City	R.	439.1	126.21	.20	126.01	.08	2.3	0.035	Nov. 11	12 m.
50	Near Eunice	R.	442.5	126.10	.38	125.72	.29	3.4	.085	Nov. 12	3 p. m.
51	Offutt's Landing	L.	445.4	125.63	.40	125.23	.49	2.9	.169		4 p. m.
52	Gaine's Landing	R.	450.2	124.66	.58	124.08	1 15	4.8	.240	Nov. 13	8 a. m.

* United States gauge.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW-WATER SLOPE OF 1882—Continued.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
53	Near Point Comfort	R.	453. 8	123. 89	—. 59	123. 30	.78	3. 6	.217	.....	10 a. m.
54	Shadyside	L.	457. 4	123. 00	.61	122. 39	.91	3. 6	.253	.....	12 m.
55	Tarpley Plant	L.	461. 5	121. 44	.63	120. 81	1. 58	4. 1	.385	.....	2 p. m.
56	Lewellyn, Ark	R.	464. 7	121. 28	.64	120. 64	.17	3. 2	.053	.....	5 p. m.
57	Luna, Ark	R.	467. 5	120. 04	.81	119. 23	1. 41	2. 8	.504	Nov. 14	7 a. m.
58	Opposite Point Chicot	L.	475 8	118. 88	.82	118. 06	1. 17	8. 3	.141	.....	10 a. m.
59	Greenville	L.	478. 5	117. 86	.85	117. 01	1. 05	2. 7	.389	.....	1 p. m.
60	Jack	L.	481. 7	117. 43	.86	116. 57	.44	3. 2	.138	.....	4 p. m.
61	Leland Plant	R.	483. 5	116. 30	.87	115. 43	1. 14	1. 8	.633	.....	5 p. m.
62	Vaucluse Landing	R.	487. 1	115. 77	.98	114. 79	.64	3. 6	.178	Nov. 15	7 a. m.
63	Sunnyside Landing	R.	490. 0	114. 32	.98	113. 34	1. 45	2. 9	.500	.....	8 a. m.
64	Walnut Point Landing	L.	494. 8	.....	.97	.....	.....	.....	.....	.....	10 a. m.
65	Lake Port Landing	L.	496. 1	113. 22	.98	112. 24	1. 10	6. 1	.180	.....	12 m.
66	Glenora, Miss	L.	499. 5	112. 77	.99	111. 78	.46	3. 4	.135	.....	2 p. m.
67	Longwood	L.	502. 1	112. 28	1. 01	111. 27	.57	2. 6	.196	.....	4 p. m.
68	Rosebank	R.	507. 8	109. 97	1. 00	108. 97	2. 30	5. 7	.493	.....	5 p. m.
69	Near Leota Landing	L.	513. 0	108. 79	1. 20	107. 59	1. 38	5. 2	.265	Nov. 16	8 a. m.
70	Carolina Landing	L.	517. 0	107. 98	1. 21	106. 77	.82	4. 0	.205	.....	9 a. m.
71	Ashton Landing	R.	520. 5	107. 68	1. 22	106. 46	.31	3. 5	.089	.....	11 a. m.
72	Near Pilcher's Landing	R.	523. 0	106. 57	1. 24	105. 33	1. 13	2. 5	.452	.....	12 m.
73	Pitman's Landing	R.	526. 0	105. 08	1. 26	103. 82	1. 51	3. 0	0. 503	Nov. 16	3 p. m.
74	Wilson's Point	L.	531. 3	104. 06	1. 46	102. 60	1. 22	5. 3	.230	Nov. 17	7 a. m.
75	Opposite Wilson's Point	L.	532. 0	103. 54	1. 44	102. 10	0. 50	0. 7	.714	.....	6 a. m.
76	Vista Landing	R.	536. 5	101. 76	1. 44	100. 32	1. 78	4. 5	.396	.....	9 a. m.
77	Head of Stack Island	L.	539. 6	100. 38	1. 47	98. 91	1. 41	3. 1	.455	.....	12 m.
78	Lake Providence	R.	543. 0	99. 10	1. 46	97. 64	1. 27	3. 4	.374	.....	12 m.
79	Shipland Landing	L.	544. 7	97. 69	1. 48	96. 21	1. 43	1. 7	.841	.....	2 p. m.
80	Bass Bend Landing										*
81	Hay's Landing (opposite)	R.	553. 2	94. 02	1. 70	92. 32	3. 89	8. 5	.458	Nov. 18	6 a. m.
82	Cottonwood Landing	L.	556. 7	93. 26	1. 74	91. 52	0. 80	3. 5	.229	.....	9 a. m.
83	Wilson's Landing	R.	559. 7	91. 71	1. 77	89. 94	1. 58	3. 0	.527	.....	10 a. m.
84	Edgewood Landing	R.	563. 7	90. 63	1. 81	88. 82	1. 12	4. 0	.280	.....	12 a. m.
85	Near Foster's Landing	R.	567. 0	88. 20	1. 83	86. 37	2. 45	3. 3	.742	.....	2 p. m.
86	Chotard's Landing	L.	570. 4	86. 22	1. 86	84. 36	2. 01	3. 4	.591	.....	3 p. m.
87	Henderson's Landing	R.	573. 5	85. 35	1. 89	83. 46	0. 90	3. 1	.290	.....	5 p. m.
88	Omega Landing	R.	578. 1	84. 14	2. 08	82. 06	1. 40	4. 6	.304	Nov. 19	7 a. m.
89	Below Omega	R.	578. 8	83. 72	2. 12	81. 60	0. 46	0. 7	.657	.....	10 a. m.
90	Above Cabin Teele	R.	583. 0	81. 76	2. 13	79. 63	1. 97	4. 2	.469	.....	10 a. m.
91	Halpins Landing	L.	585. 7	80. 47	2. 24	78. 23	1. 40	2. 7	.518	.....	4 p. m.
92	Foot of Paw Paw Island	R.	589. 9	78. 79	2. 54	76. 25	1. 98	4. 2	.471	ov. 20	7 a. m.
93	Young's Point	R.	594. 0	78. 03	2. 60	75. 43	0. 82	4. 1	.200	.....	9 a. m.
94	King's Point	L.	596. 6	77. 53	2. 68	74. 85	0. 58	2. 6	.223	.....	12 m.
95	Vicksburg or Kleinston	L.	599. 2	77. 89	3. 62	74. 27	0. 58	2. 6	.223	Nov. 23	2 p. m.
96	Delta Landing	R.	601. 9	77. 70	4. 01	73. 69	0. 58	2. 7	.215	Nov. 25	4 p. m.
97	Warrenton	L.	606. 7	75. 55	4. 03	71. 52	2. 17	4. 8	.452	Nov. 26	8 a. m.
98	Diamond Point	L.	611. 1	74. 14	3 96	70. 18	1. 34	4. 4	0. 305	Nov. 26	10 a. m.
99	Moore's Landing	R.	614. 2	73. 16	3. 92	69. 24	0. 94	3. 1	0. 303	.....	12 a. m.
100	New Town Landing	L.	618. 5	71. 79	3. 84	67. 95	1. 29	4. 3	.300	.....	2 p. m.
101	Point Pleasant	R.	622. 2	71. 18	3. 82	67. 36	0. 59	3. 7	.159	Nov. 27	7 a. m.
102	Brook's Landing	L.	626. 0	70. 24	3. 75	66. 49	0. 87	3. 8	.229	.....	9 a. m.
103	Wilson's Point	R.	631. 2	69. 64	3. 66	65. 98	0. 51	5. 2	.098	.....	11 a. m.
104	Coffee's Point	R.	633. 8	68. 02	3. 61	64. 41	1. 57	2. 6	.604	.....	1 p. m.
105	Near Whitehall Landing	L.	636. 6	67. 75	3. 58	64. 17	0. 24	2. 8	.086	.....	2 p. m.
106	Above Saint Joseph	L.	641. 0	66. 43	3. 51	62. 92	1. 25	4. 4	284	.....	4 p. m.
107	Saint Joseph, La	R.	647. 7	64. 25	3. 51	60. 74	2. 18	6. 7	.325	Nov. 28	7 a. m.
108	Rodney	L.	651. 1	64. 04	3. 57	60. 47	0. 27	3. 4	.079	.....	9 a. m.
109	Beeler's Landing	R.	655. 2	63. 39	3. 65	59. 74	0. 73	4. 1	.178	.....	11 a. m.
110	Kemp's Landing	R.	659. 8	60. 53	3. 74	56. 79	2. 95	4. 6	.641	.....	1 p. m.
111	Below Waterproof	R.	664. 6	58. 30	3. 81	54. 49	2. 30	4. 8	.479	.....	3 p. m.
112	Cypress Grove	L.	668. 9	57. 29	3. 89	53. 40	1. 09	4. 3	.254	.....	4 p. m.
113	Cole's Creek Landing	L.	672. 0	56. 76	4. 02	52. 74	0. 66	3. 1	.213	Nov. 29	6 a. m.
114	Above L'Argent	R.	676. 0	55. 27	4. 10	51. 17	1. 57	4. 0	.392	.....	8 a. m.
115	L'Argent Landing	R.	679. 3	55 21	4. 16	51. 05	0. 12	3. 3	.036	.....	9 a. m.
116	Gibson's Landing	R.	683. 4	53. 98	4. 24	49. 74	1. 31	4. 1	.320	.....	11 a. m.
117	Opposite Good Hope	L.	690. 4	52. 60	4. 38	48. 22	1. 52	7. 0	.217	.....	1 p. m.
118	Stacy Plantation	R.	696. 6	51. 55	4. 50	47. 05	1. 17	6. 2	.189	.....	4 p. m.
119	Natchez	L.	699. 2	51. 60	4. 95	46. 65	0. 40	2. 6	.154	Dec. 1	7 p. m.

*Reference bench-mark not connected with.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW-WATER SLOPE OF 1883.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
1	Cairo, Ill			298.69	—3.15	295.54				Oct. 11	12 m.
2	Head of Island No. 1	L.	5.8					5.8			1 p. m.
3	△Beckwith	R.	8.8					3.0			2 p. m.
4	Head of Puntney Bend	L.	10.3					1.5			2 p. m.
5	Foot of Puntney Bend	R.	14.1					3.8			3 p. m.
6	△Cannon	R.	18.0	295.21	3.32	291.89	3.65	3.9	0.203		4 p. m.
7	△Iron Bank	L.	20.1	297.10	5.35	291.75	0.14	2.1	.067	Oct. 22	2 p. m.
8	Columbus	L.	21.2	295.05	3.32	291.73	0.02	1.1	.018	Oct. 11	12 m.
9	△Wiggins	L.	27.3	291.79	3.36	288.43	3.30	6.1	.541	Oct. 12	7 a. m.
10	Below Farris Landing	R.	29.8	290.99	3.33	287.66	0.77	2.5	.308		8 a. m.
11	Thomas McMahan's	R.	32.6	289.84	3.30	286.54	1.12	2.8	.400		8 a. m.
12	Near Salmon's Landing	L.	34.6	289.36	3.30	286.06	0.48	2.0	.240		9 a. m.
13	French's Point	L.	39.7	288.64	3.25	285.39	0.67	5.1	.131		10 a. m.
14	Saint James's Bayou	R.	44.5	287.06	3.21	283.85	1.54	4.8	.321		11 a. m.
15	One mile below Lavalle's Landing	R.	48.2					3.7			
16	△Mitcham	L.	49.9	286.29	3.17	283.12	0.73	1.7	.135		1 p. m.
17	Stewart's Landing	L.	59.5	284.04	3.08	280.96	2.16	9.6	.225		2 p. m.
18	△Bryant's Point	R.	62.9	282.04	3.05	278.99	1.97	3.4	.579		3 p. m.
19	Howard's	L.	66.1	281.06	3.03	278.03	0.96	3.2	.300		4 p. m.
20	Morrison's Landing	R.	68.9	280.74	2.98	277.76	0.27	2.8	.096		12 m.
21	Below Morrison's Landing	R.	69.2	280.60	2.99	277.61	0.15	0.3	.500		4 p. m.
22	Marr's Landing	L.	77.3	276.24	3.02	273.22	4.39	8.1	.542	Oct. 13	7 a. m.
23	Below Point Pleasant	R.	80.3	273.25	3.01	270.24	2.98	3.0	.993		7 a. m.
24	Lazelle's Landing	R.	82.4					2.1			8 a. m.
25	Above Tiptonville	L.	84.3					1.9		Oct. 13	9 a. m.
26	Opposite Tiptonville	R.	85.3					1.0			9 a. m.
27	Riley's Landing	L.	87.7	267.82	3.00	264.82	5.42	2.4	.732		11 a. m.
28	Below Stewart's Landing	R.	89.7	266.71	3.00	263.71	1.11	2.0	.555		12 m.
29	Foot of Little Cypress Bend	R.	93.3		2.98			3.6			1 p. m.
30	Bass' Landing	L.	95.1	265.49	2.97	262.52	1.19	1.8	.220		1 p. m.
31	Hathaway's (above)	L.	101.7	365.02	2.93	262.09	0.43	6.6	.065		3 p. m.
32	Below Mott's Landing	R.	104.2	261.22	2.93	*258.29	3.80	2.5	1.520		3 p. m.
33	Bell's Point	R.	112.0	260.31	2.89	257.42	0.87	7.8	.112		4 p. m.
34	Above Linwood Field	L.	114.2	258.36	2.91	255.45	1.97	2.2	.895	Oct. 14	6 a. m.
35	Mitchell's Point	L.	121.9	259.53	2.89	256.64		7.7			8 a. m.
36	Cottonwood Point	R.	123.1	254.52	2.90	251.62	3.83	1.2	.430		12 m.
37	Helm's	R.	123.6	254.20	2.88	251.32	0.30	0.5	.600		9 a. m.
38	Hickman's Landing	R.	131.3	255.02	2.76	252.26		7.7			10 a. m.
39	Above Rucker's Point	L.	138.2	248.81	2.64	246.17	5.15	6.9	.353		11 a. m.
40	Buckner's Landing	R.	139.8	249.21	2.61	246.60		1.6			12 m.
41	Above T. H. of Island No. 25	R.	142.9	247.61	2.57	245.04	1.13	3.1	.240		12 m.
42	Two miles above Forked Deer Island	L.	145.4	247.31	2.52	244.79	0.25	2.5	.100		1 p. m.
43	One mile below head of Forked Deer Island	L.	143.0	246.56	2.48	244.08	0.71	2.6	.273		2 p. m.
44	O'Donnell's Landing	R.	149.3					1.3			
45	Ashport, Tenn	L.	153.3					4.0			
46	Gold Dust Landing	L.	156.2					2.9			
47	Fletcher's Landing	R.	158.0					1.8			
48	T. H. of Osceola Bar	R.	163.2					5.2			
49	Driver's Landing	R.	166.0					2.8			
50	△Yankee Bar	L.	165.9					—0.1			
51	Below Tanza's Landing	R.	167.7					1.8			
52	Fort Pillow	L.	171.9					4.2			
53	Fulton, Tenn	L.	175.4	235.25	2.02	233.23	10.85	3.5	.396	Oct. 16	12 m.
54	Dixie Landing	R.	178.5	233.35	2.02	231.33	1.90	3.1	.613		8 a. m.
55	Hatchee River	L.	180.0	231.67	2.02	229.65	1.68	1.5	1.120		7 a. m.
56	Pierce's	R.	182.1	229.91	2.03	227.88	1.77	2.1	.843		7 a. m.
57	Half mile below Randolph	L.	183.4	229.78	2.04	227.74	0.14	1.3	.108	Oct. 15	5 p. m.
58	Richardson's Landing	L.	185.3	229.78	2.05	227.73	0.01	1.9	.005		5 p. m.
59	Above Pecan Point	R.	195.1	223.70	2.06	221.64	6.09	9.8	.621		3 p. m.
60	Below Andrew's Landing	L.	198.5	224.72	2.07	222.65		3.4			1 p. m.
61	Below Thomas' Landing	L.	202.3	220.39	2.07	218.32	3.32	3.8	.461		12 m.
62	Corona Landing	R.	203.8	220.35	2.07	218.28	0.04	1.5	.027		12 m.
63	Brandywine Island	L.	206.5	218.86	2.07	216.79	1.49	2.7	.552		11 a. m.

* Data considered doubtful.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW-WATER SLOPE OF 1883—Continued.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
64	Scudder Landing	R.	207.8	216.91	—2.07	214.84	1.95	1.3	1.500		10 a. m.
65	Randolph Point	L.	210.9	216.66	2.06	214.60	0.24	3.1	.077		5 p. m.
66	Mitchell's Landing	L.	212.9	215.13	2.12	213.01	1.59	2.0	*.795	Oct. 17	3 p. m.
67	Below Bradley's Landing	R.	215.2	216.18	2.00	214.18		2.3		Oct. 16	11 a. m.
68	Holly Bush Landing	R.	219.7	212.62	2.00	210.62	2.39	4.5	.351		12 m.
69	Ash Slough	L.	221.8	211.25	2.00	209.25	1.37	2.1	.652		1 p. m.
70	Above Old Hen Island	L.	224.1	210.34	2.00	208.34	0.91	2.3	.396		1 p. m.
71	Upper end Chicken Island	R.	225.8					1.7			1 p. m.
72	Memphis, Tenn	L.	230.3	208.16	2.07	206.09	2.25	4.5	.363	Oct. 17	6 a. m.
73	Fort Pickering	L.	232.1	202.54	2.11	200.43		1.8		Oct. 17	7 a. m.
74	Wreck of Gen. Beauregard	R.	233.2					1.1			8 a. m.
75	Four Mile Bayou	R.	235.6	207.09	2.18	204.91	1.18	2.4	0.223		8 a. m.
76	Jones' Landing	R.	238.9	203.27	2.26	201.01	3.90	3.3	1.182		9 a. m.
77	Above Reeves Landing	R.	242.6	201.26	2.33	198.93	2.08	3.7	.562		10 a. m.
78	Coahoma Field	L.	244.1					1.5			12 m.
79	Scanlan's Landing	R.	247.7					3.6			1 p. m.
80	Cat Island	R.	253.0	196.20	2.58	193.62	5.31	5.3	.511		2 p. m.
81	Norfolk Landing	L.	254.3	194.47	2.60	191.87	1.75	1.3	1.346		2 p. m.
82	Star Landing	L.	258.2	199.03	2.70	196.33		3.9			3 p. m.
83	Polk's Landing	L.	264.3	192.65	2.81	189.84	2.03	6.1	.203		5 p. m.
84	Excelsior Landing	R.	266.5	192.38	2.94	189.44	0.40	2.2	.182	Oct. 1	7 a. m.
85	Near Commerce	L.	269.8	189.86	3.00	186.86	2.58	3.3	.782		8 a. m.
86	Campbell's Landing	R.	272.5	187.80	3.04	184.76	2.10	2.7	.778		8 a. m.
87	Mhoon's Landing	L.	275.8	187.00	3.12	183.88	0.88	3.3	.267		12 m.
88	Bordeaux Landing	L.	278.5	185.35	3.06	182.29	1.59	2.7	.589		11 a. m.
89	Head Bordeaux Chute	L.	279.5	183.46	3.03	180.43	1.86	1.0	1.860		11 a. m.
90	Walnut Bend Landing	R.	282.6	183.26	2.97	180.29	0.14	3.1	.045		12 m.
91	Hardin's Point	R.	285.8	181.24	2.91	178.33	1.96	3.2	.612		12 m.
92	O. K. Landing	L.	289.4	180.90	2.85	178.05	0.28	3.6	.078		2 p. m.
93	Harbert's Landing	L.	292.6	178.10	2.79	175.31	2.74	3.2	.856		2 p. m.
94	Head St. Francis Island	R.	296.9	174.80	2.70	172.10	3.21	4.3	.747		3 p. m.
95	Prairie Point	R.	300.3	173.56	2.66	170.90	1.20	3.4	.353		4 p. m.
96	Trotters' Landing	L.	304.0					3.7			5 p. m.
97	Helena, Ark	R.	306.5	170.83	2.45	168.38	2.52	2.5	.406	Oct. 18	12 m.
98	Below William's Landing	R.	310.9	170.26	2.91	167.35	1.03	4.4	.234	Oct. 19	8 a. m.
99	Thompson's Landing	L.	313.0	167.85	2.94	164.91	2.44	2.1	1.162		9 a. m.
100	Near Craig's Landing	R.	316.2	166.57	2.96	163.61	1.30	3.2	.406		10 a. m.
101	Miller's Point	R.	324.7					8.5			11 a. m.
102	Allison's Landing	R.	327.7					3.0			12 m.
103	Foot of Island No. 63	L.	332.8	161.69	3.07	158.62	4.99	5.1	.301		1 p. m.
104	Modoc Landing	R.	334.5	161.31	3.08	158.23	0.39	1.7	.229		1 p. m.
105	Near Robinson's Landing	L.	338.2	159.52	3.11	156.41	1.82	3.7	.492		2 p. m.
106	Jackson's Point	L.	341.6	159.06	3.14	155.92	0.49	3.4	.144		3 p. m.
107	Head of Island No. 65	R.	343.2	158.65	3.14	155.51	0.41	1.6	.256		3 p. m.
108	Offut's Landing	R.	346.7	158.55	3.17	155.38	0.13	3.5	.037		4 p. m.
109	Saint Louis Landing	R.	349.5	157.38	3.19	154.19	1.19	2.8	.425		5 p. m.
110	Above Fish Lake	L.	350.8					1.3			6 p. m.
111	Sunflower Landing	L.	352.7	155.99	3.38	152.61	1.58	1.9	.494	Oct. 20	7 a. m.
112	Pushmataha	L.	359.4	154.87	3.70	151.17	1.44	6.7	.215		8 a. m.
113	Knowlton's Landing	R.	366.6	153.35	4.03	149.32	1.85	7.2	.257		9 a. m.
114	Australia	L.	370.0	149.33	4.21	145.12	4.20	3.4	1.235		10 a. m.
115	Laconia	R.	373.7	148.19	4.40	143.79	1.33	3.7	.359		10 a. m.
116	Below Lulu Landing	R.	376.8					3.1			11 a. m.
117	Maysonia Landing	L.	378.4	146.74	4.64	142.10	1.69	1.6	.360		12 m.
118	Frawley's Landing	L.	382.1	146.27	4.84	141.43	0.67	4.0	.168		12 m.
119	Head Scrub Grass Bend	R.	385.3					2.9			1 p. m.
120	Barnett's Landing	R.	387.0	142.51	5.09	137.42	4.01	1.7	.872		1 p. m.
121	McGeehee's Landing	L.	391.4	140.74	5.29	135.45	1.97	4.4	.448	Oct. 20	2 p. m.
122	Cumbyville	R.	394.4	140.94	5.45	135.49	—0.04	3.0	—.013		3 p. m.
123	Malone's Landing, Ark	R.	397.8					3.4			4 p. m.
124	Rosedale	L.	398.4	140.37	5.48	134.89	0.60	0.6	.150		4 p. m.
125	Glen Low Landing	R.	401.9					3.5			5 p. m.
126	Prentiss Landing	L.	403.7	138.95	5.54	133.41	1.48	1.8	.279		6 p. m.
127	Below foot Island No. 75	R.	407.4					3.7		Oct. 21	6 a. m.
128	Caulk's Landing	R.	413.3					5.9			7 a. m.
129	Bolivar, Miss	L.	417.0	133.88	5.84	128.04	5.37	3.7	.404		8 a. m.
130	Near Cat-Fish Point										9 a. m.

*Data considered doubtful.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW-WATER SLOPE OF 1883—Continued.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation. Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
131	Cat-Fish Point Landing	L.	422.7	132.54	—5.90	126.64	1.40	5.7	.246		9 a. m.
132	Head Cypress Bend	R.	423.7					1.0			10 a. m.
133	Above Chicot City	L.	430.9					7.2			11 a. m.
134	Mound Place	R.	435.5	127.63	6.02	121.61	5.03	4.6	.393		12 m.
135	Arkansas City	R.	438.3	126 65	6.05	120.60	1.01	2.8	.361		1 p. m.
136	Old Eunice Landing	L.	442.3					4.0			2 p. m.
137	Offut's Landing	R.	444.7	125.71	5.83	119.88	0.72	2.4	.112		3 p. m.
138	Gaines's Landing	R.	449.6	124.74	5.58	119.16	0.72	4.9	.147		3 p. m.
139	Old Point Comfort	L.	454.5					4.9			4 p. m.
140	Head Miller's Bend Landing	L.	455.5					1.0			5 p. m.
141	Woodstock Landing	L.	464.2					8.7			5 p. m.
142	Llewellyn, Ark	R.	464.3	121.65	5.13	116.52	2.64	0.1	.180	Oct. 22	6 a. m.
143	Chicot Landing	R.	473.0					8.7			7 a. m.
144	⚓ Carter	L.	474.2					1.2			
145	Greenville	L.	478.5	118.18	4.56	113.62	2.90	4.3	.204	Oct. 22	12 m.
146	⚓ Jack	L.	481.7	117.71	4.50	113.21	0.41	3.2	.128		9 a. m.
147	Craig's Landing	R.	483.5	116.61	4.52	112.09	1.12	1.8	.622		10 a. m.
148	Vaucluse Landing	R.	486.9					3.4			11 a. m.
149	Sunnyside Landing	R.	490.0					3.1			11 a. m.
150	Above Walnut Point	L.	493.9					3.9			12 m.
151	Lake Port Landing	R.	495.4	112.99	4.54	108.45	3.64	1.5	.306		1 p. m.
152	Glenora, Miss	L.	498.5	112.56	4.54	108.02	0.43	3.1	.139		1 p. m.
153	Longwood Landing	L.	501.3					2.8			2 p. m.
154	Rosebank, Ark	R.	507.0	109.82	4.54	105.28	2.74	5.7	.322		3 p. m.
155	Barnard Landing	R.	509.9	109.16	4.54	104.62	0.66	2.9	.228		4 p. m.
156	Near Leota Landing	L.	511.6					1.7			5 p. m.
157	Sterling Landing	R.	515.1					3.5			5 p. m.
158	Carolina Landing	L.	516.8	107.38	4.73	102.65	1.97	1.7	.286	Oct. 23	6 a. m.
159	Ashton Landing	R.	520.5	107.16	4.74	102.42	0.23	3.7	.062		7 a. m.
160	Pilcher's Point Landing	R.	523.8	104.08	4.74	99.34		3.3			8 a. m.
161	Below Lewis Plantation	L.	526.1	106.40	4.75	101.65	0.77	2.3	.137		9 a. m.
162	Opossum Point	R.	529.2	104.44	4.74	99.70	1.95	3.1	.629		9 a. m.
163	Opposite Wilson's Point	L.	531.8	103.76	4.74	99.02	0.68	2.6	.262		10 a. m.
164	Vista Landing	R.	536.5	101.83	4.75	97.08	1.94	4.7	.413		11 a. m.
165	Below Longwood Landing	R.	538.1					1.6			12 m.
166	Lake Providence	R.	542.3	98.77	4.75	94.02	3.06	4.2	.528		12 m.
167	Below Lake Providence	R.	543.0	98.41	4.80	93.61	0.41	0.7	.586		2 p. m.
168	Shipland Landing	L.	544.7	97.25	4.83	92.42	1.19	1.7	.700		3 p. m.
169	Bass Bend, La	R.	548.8					4.1		Oct. 23	3 p. m.
170	Cottonwood Landing	L.	556.7	90.94	4.96	85.98	6.44	7.9	.537		4 p. m.
171	Edgewood Landing	R.	563.8					7.1			5 p. m.
172	Pecan Grove Landing	R.	566.3					2.5		Oct. 24	6 a. m.
173	Chotard's Landing	L.	570.4	84.79	5.36	79.43	6.55	4.1	.478		7 a. m.
174	Henderson's Landing	R.	573.5	84.12	5.41	78.71	0.72	3.1	.232		8 a. m.
175	Omega Landing	R.	578.0					4.5			8 a. m.
176	Cabin Teele Landing	R.	584.3					6.3			9 a. m.
177	Below Duckport	R.	589.9	76.63	5.61	71.02	7.69	5.6	.469		10 a. m.
178	Young's Point	R.	593.4					3.5			11 a. m.
179	King's Point, Miss	L.	596.6	75.28	5.72	69.56	1.46	3.2	.218		12 m.
180	Kleinston or Vicksburg	L.	599.2	74.56	5.76	68.80	0.76	2.6	.292		1 p. m.
181	Warrenton, Miss	L.	606.7	72.34	5.88	66.46	2.34	7.5	.312	Oct. 25	7 a. m.
182	Diamond Point	L.	612.1		5.69			5.4			9 a. m.
183	Moore's Landing, La	R.	614.2	69.58	5.60	63.98	2.48	2.1	.331		9 a. m.
184	Upper New Town Landing	L.	618.1		5.47			3.9			10 a. m.
185	Point Pleasant Landing	R.	622.3		5.32			4.2			11 a. m.
186	Brook's Landing	L.	626.2	66.92	5.17	61.75	2.23	3.9	.186		12 m.
187	Wilson's Point Landing	R.	631.2	66.62	5.00	61.62	0.13	5.0	.026		12 m.
188	Coffee's Point	R.	634.5		4.88			3.3			1 p. m.
189	Whitehall Landing	L.	637.2	65.23	4.79	60.44	1.18	2.7	.197		2 p. m.
190	Above Bayou Pierre	L.	641.6	63.77	4.63	59.14	1.30	4.4	.295		3 p. m.
191	Saint Joseph	R.	648.3	61.38	4.37	57.01	2.13	6.7	.318		4 p. m.
192	Rodney	L.	652.0	61.10	4.44	56.66	0.35	3.7	.095		5 p. m.
193	Beeler's Landing	R.	655.3	60.73	4.52	56.21	0.45	3.3	.136	Oct. 25	6 p. m.
194	Kemp's Landing	R.	659.7		4.82			4.4		Oct. 26	6 a. m.
195	Below Waterproof	R.	665.2		4.91			5.5			7 a. m.
196	Cypress Grove	L.	669.7	54.35	4.99	49.36	6.85	4.5	.476		8 a. m.
197	Cole's Creek Landing	L.	672.0	53.28	5.03	48.25	1.11	2.3	.483		9 a. m.

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW-WATER SLOPE OF 1883—Continued.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
198	Two and three-fourths miles above L'Argent Landing	R.	676.3	52.91	—5.10	47.81	0.44	4.3	.102	.....	9 a. m.
199	L'Argent Landing	R.	679.3	51.75	5.16	46.59	1.22	3.0	.407	.....	10 a. m.
200	Gibson's Landing	R.	683.5	50.50	5.22	45.28	1.31	4.2	.312	.....	10 a. m.
201	Moses's Wood-yard	L.	689.3	49.18	5.32	43.86	1.42	5.8	.245	.....	12 m.
202	Stacy Plantation	R.	696.6	.....	5.45	.....	.....	7.3	.....	.....	12 m.
203	Natchez, upper end	L.	699.6	48.13	5.50	42.63	1.23	3.0	.119	.....	1 p. m.
204	Natchez Gauge	L.	700.4	47.43	5.50	41.93	0.70	0.8	.875	.....	12 m.
205	Carthage Landing	L.	703.1	47.26	5.53	41.73	0.20	2.7	.074	.....	2 p. m.
206	Boies Point	R.	707.4	45.25	5.51	39.74	1.99	4.3	.463	.....	3 p. m.
207	Opposite Morville Landing	L.	710.5	44.82	5.49	39.33	0.41	3.1	.132	.....	3 p. m.
208	Apex of Saint Catherine Bend	R.	712.7	.....	5.50	.....	.....	2.2	.....	.....	4 p. m.
209	Avalanche Landing	L.	718.3	.....	5.46	.....	.....	5.6	.....	.....	4 p. m.
210	Green's Landing	R.	720.5	40.82	5.46	35.36	3.97	2.2	.397	.....	5 p. m.
211	Below Ashley Plantation	R.	724.2	.....	5.71	.....	.....	3.7	.....	Oct. 27	6 a. m.
212	Fairview Landing	R.	727.6	39.35	5.70	33.65	1.71	3.4	.241	.....	7 a. m.
213	In Dead Man's Bend	L.	730.8	39.35	5.69	33.66	—0.01	3.2	—.003	.....	8 a. m.
214	Allaway's Landing	L.	735.4	38.45	5.68	32.77	0.89	4.6	.193	.....	9 a. m.
215	Bougere Landing	R.	737.9	41.18	5.67	35.51	.....	2.5	.....	.....	10 a. m.
216	Above Union Point Landing	R.	741.0	.....	5.67	.....	.....	3.1	.....	.....	11 a. m.
217	Kienstra Landing	L.	742.9	37.04	5.66	31.38	1.39	1.9	0.185	Oct. 27	12 m.
218	Black Hawk Landing	R.	747.2	36.35	5.64	30.71	0.67	4.3	.156	.....	12 m.
219	Stamp's Landing	L.	750.8	.....	5.63	.....	.....	3.6	.....	.....	1 p. m.
220	Knox's Landing	R.	753.0	35.55	5.62	29.93	0.78	2.2	.134	.....	2 p. m.
221	Fort Adams	L.	755.2	.....	5.61	.....	.....	2.2	.....	.....	3 p. m.
222	Lum's Landing	R.	758.0	35.19	5.59	29.60	0.33	2.8	.066	.....	3 p. m.
223	Point Old River and Miss.	R.	764.2	.....	5.56	.....	.....	6.2	.....	.....	4 p. m.
224	Red River Landing	R.	765.3	33.69	5.56	28.13	1.47	1.1	.201	.....	4 p. m.
225	Hog Point Landing	R.	767.0	33.45	5.71	27.74	0.39	1.7	.229	Oct. 28	6 a. m.
226	Bayou Tunica	L.	773.0	32.46	5.56	26.90	0.84	6.0	.140	.....	8 a. m.
227	Greenwood Landing	L.	777.0	32.12	5.45	26.67	0.23	4.0	.058	.....	8 a. m.
228	Brunette Light Landing	R.	779.5	31.81	5.37	26.44	0.23	2.5	.092	.....	9 a. m.
229	Sebastopol Landing	L.	782.2	.....	5.30	.....	.....	2.7	.....	.....	9 a. m.
230	Raccourci Landing	R.	784.8	31.10	5.22	25.88	0.56	2.6	.106	.....	10 a. m.
231	Morganza Crevasse	R.	789.1	.....	5.12	.....	.....	4.3	.....	.....	11 a. m.
232	Head Arrow Bend	....	791.9	.....	5.04	.....	.....	2.8	.....	.....	11 a. m.
233	Mann's Landing	....	795.1	30.01	4.96	25.05	0.83	3.2	.081	.....	12 m.
234	Point Coupée	R.	797.9	29.96	4.86	25.10	—0.05	2.8	—.018	.....	12 m.
235	Bayou Sara	L.	799.5	29.39	4.83	24.56	0.54	1.6	.338	.....	1 p. m.
236	Waterloo, La.	R.	805.2	29.35	4.68	24.67	—0.11	5.7	—.019	.....	2 p. m.
237	Hermitage Landing	R.	807.8	28.58	4.62	23.96	0.71	2.6	.273	.....	2 p. m.
238	Port Hickey	L.	810.0	28.36	4.56	23.80	0.16	2.2	.073	.....	3 p. m.
239	Kelson's Store	R.	813.6	28.12	4.38	23.74	0.06	3.6	.017	.....	4 p. m.
240	Lower Springfield Landing	L.	818.9	.....	4.14	.....	.....	5.3	.....	.....	5 p. m.
241	Grossman's Landing	R.	822.6	28.01	3.94	24.07	—0.33	3.7	—.037	Oct. 28	5 p. m.
242	Belle Valle Plantation	R.	825.5	27.62	4.03	23.59	+0.48	2.9	+.166	Oct. 29	6 a. m.
243	Scotland Landing	L.	828.5	27.14	3.87	23.27	0.32	3.0	.107	.....	7 a. m.
244	Baton Rouge	L.	833.3	27.36	3.63	23.73	—0.46	4.8	—.096	.....	8 a. m.
245	Arlington Plantation	L.	836.9	26.90	3.48	23.42	+0.31	3.6	+.086	.....	9 a. m.
246	Conrad's Cottage Plantation	L.	840.0	26.49	3.39	23.10	0.32	3.1	.103	.....	9 a. m.
247	Saint Mary Plantation	R.	841.0	.....	3.34	.....	.....	1.0	.....	.....	9 a. m.
248	Hollywood	L.	845.0	26.38	3.31	23.07	0.03	4.0	.006	.....	10 a. m.
24	Above Plaquemine	L.	847.2	25.11	3.23	21.88	....	2.2	.....	.....	12 m.
25	Plaquemine	R.	853.5	25.78	2.87	22.91	0.16	6.3	.019	.....	12 m.
25	Rebecca Plantation	R.	856.6	21.21	2.80	18.41	.....	3.1	.....	.....	1 p. m.
25	Saint Gabriel's Church	L.	861.6	25.58	2.68	22.90	0.01	5.0	.001	.....	2 p. m.
25	Above Bayou Goula	L.	864.9	25.46	2.60	22.86	0.04	3.3	.012	.....	3 p. m.
254	Cora Plantation	R.	868.8	.....	2.50	.....	.....	3.9	.....	.....	3 p. m.
25	Indian Camp Plantation	L.	870.8	25.31	2.45	22.86	0.00	2.0	.000	.....	4 p. m.
25	Southwood Plantation	L.	874.4	24.94	2.36	22.58	0.28	3.6	.078	.....	4 p. m.
25	Ashland Landing	L.	878.2	25.06	2.28	22.78	—0.20	3.8	—.053	.....	5 p. m.
25	New Hope Plantation	L.	881.6	.....	2.19	.....	.....	3.4	.....	.....	5 p. m.
25	Above Donaldsonville	L.	884.4	25.10	2.21	22.89	—0.11	2.8	—.018	Oct. 30	6 a. m.
26	Riverside, La	R.	887.1	25.27	2.16	23.11	—0.22	2.7	—.081	.....	7 a. m.
261	Houma's Estate	L.	889.7	.....	2.10	.....	.....	2.6	.....	.....	.....

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Tables of high and low water elevations and slopes, Mississippi River—Continued.

LOW-WATER SLOPE OF 1883—Continued.

No. of station.	Locality of station.	Bank.	Distance from Cairo.	Observed elevation of W. S. Cairo datum.	Correction for change of gauge.	Corrected elevation of W. S. Cairo datum.	Fall between stations.	Distance between stations.	Slope, feet, per mile.	Time of observation.	
										Day.	Hour.
			Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*			
262	Colomb's Store	L.	896.7	24.62	−1.94	22.68	+0.43	7.0	+.045		9 a. m.
263	Rome & Duhon's Store	L.	899.9		1.87			3.2			9 a. m.
264	College Point	L.	903.0	24.49	1.81	22.68	0.00	3.1	.000		10 a. m.
265	Belle Alliance Plantation	L.	907.8		1.78			4.8		Oct. 30	12 m.
266	Mount Airy Plantation	L.	915.0	24.08	1.71	22.37	0.31	7.2	.026		1 p. m.
267	Bell's Point, La	L.	916.8		1.70			1.8			1 p. m.
268	Old Bonnet Carré Post-Office	R.	926.5	23.91	1.60	22.31	0.06	9.7	.005		2 p. m.
269	Bonnet Carré Camp	L.	927.5		1.59			1.0			2 p. m.
270	Below Gypsy Plantation	L.	929.9	23.76	1.56	22.20	0.11	2.4	.032		4 p. m.
271	Myer's Landing	R.	932.0		1.54			2.1			4 p. m.
272	Fashion Landing	R.	936.7		1.50			4.7			5 p. m.
273	Kennerville	L.	947.0	23.22	1.39	21.83	0.37	10.3	.022	Oct. 31	6 a. m.
274	Willswith Plantation	R.	950.1		1.36			3.1			7 a. m.
275	Soniat's Plantation	L.	951.1	23.67	1.35	22.32		1.0			7 a. m.
276	Carrollton	L.	957.0	22.71	1.30	21.41	0.42	5.9	.042		8 a. m.
277	Near Barrataria Canal	R.	958.5		1.28			1.5			9 a. m.
278	Gretna	R.	962.6		1.24			4.1			10 a. m.
279	New Orleans (foot Canal street)	L.	964.9		1.21			2.3			10 a. m.

APPENDIX D.

REPORT OF CAPTAIN J. H. WILLARD, CORPS OF ENGINEERS, SECRETARY OF COMMITTEE ON CONSTRUCTION.

THE MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE COMMITTEE ON CONSTRUCTION,
2653 *Olive Street, Saint Louis, Mo., June* 30, 1885.

SIR: In compliance with your letter of instructions, dated June 1, 1885, I have the honor to report the work of this office from October 1, 1884, the date of my last annual report, to the close of the fiscal year, June 30, 1885.

The general service plant, comprising the Commission tow-boat Mississippi, the tow-boat Minnetonka, twenty-eight flush-deck barges, twenty-eight deck-down barges, and a few miscellaneous pieces, is now laid up in safe harbor at Twin Hollows, about 15 miles below Saint Louis.

The tow-boats are in very good order, and could be put in service at a day's notice in an emergency, the Minnetonka having been recently overhauled and strengthened and equipped with iron cylinder-timbers. The barges are in fair condition, and could all be put in service at short notice, with the exception of three, which require general repairs. All wooden hulls have been washed out, cleaned, and salted, to preserve the timbers. The bottom planking appears to be sound and the seams well filled, so that no repairs or calking will be necessary until operations are resumed, when it will be advisable to dock most, if not all, of the barges and give them a general overhauling, as they will then have been in the water about four years. The tow-boats may have to be docked for cleaning and painting, but no calking or repairs to hulls should be required. The boilers of the Mississippi should be reset before she is put on active work as a tow-boat, as the port boiler has given out repeatedly, either from defective circulation or inequality in the spaces between the shells and side-walls. An extra beam and stanchions are needed under the after end of boilers on the Minnetonka. The supports now rest on the deck between beams, causing considerable vibration, especially when running light.

The repairs to the Minnetonka were somewhat more extensive than was expected owing to developed weakness in the hull and faulty distribution of weights in placing the engines, but her behavior during the short period of service since the repairs were completed satisfied me that the money was judiciously invested. She now has the

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name of being the best tow-boat of her size on the river, and with proper attention should be good for at least eight years' service. I had her lines and dimensions taken while on the docks, from which drawings and a model are now being made for use in building the large steel tow-boat, when authority for its construction is renewed.

The thirty small barges borrowed from the Missouri River Improvement were returned in March and April in fair order. About $2,500 have been spent for docking and repairing them since October 1, 1884, which, with the sum given in my last report, makes the amount expended for their repair while in general service, about $3,700. During that time they carried and delivered 23,961 cubic yards of stone and were used temporarily for brush and timber on the reaches, so that the cost of repairs was equivalent to about 15 cents the cubic yard for transportation or to about 45 cents a day for charter. The actual cost of charter for equal capacity, computed from ruling rates, would have been about $4 a day for each barge.

These figures are interesting as bearing upon the question whether it is more advantageous to the Government to own or to charter. For works prosecuted on a large scale and requiring a term of years, such as the improvement of the Mississippi, there can be no doubtful choice. I therefore renew my request for increase of the general service plant, with the addition of small barges for service to the Ohio quarries, especially in low water, and a few medium-sized barges for delivering coal to districts The estimates are based on recent contracts for barges and for the hull of a steel snag-boat, and from informal offers for boilers, engines, and upper works, and are ample, unless there should be a very considerable advance in prices on the revival of business.

In regard to the construction of barges, the experience of the past season with the Missouri River gunwale barges leads me to recommend that form instead of the modeled barge. If planked fore and aft, with easy rakes, they will tow and handle in block almost as easily as model barges, and the saving in construction is such that they can be built of equal capacity for the same money in the proportion of about 3 to 2. Detailed drawings and specifications for both sizes of barge are now ready, and drawings, specifications, and models for the tow-boats are well in hand, those for the hull of the small tow-boat being finished.

I also renew the suggestions contained in my last report in regard to the purchase and delivery of Illinois coal. Eleven well-built coal barges of, say, 9,000 bushels capacity, would be enough to supply the three districts below Cairo and the general service, and would pay for themselves in one year on the basis of prices and amounts of last year's purchases. If it still be thought better to buy Pittsburgh coal for the districts, it should be contracted for delivery at the works, or, if received at Cairo, should be delivered by the general service at the first opportunity. It would certainly conduce to economy of the service to have three or four coal barges of moderate capacity to accompany the tow-boats on long trips. Prices last year ranged from 11¼ cents at Cairo to 16¾ cents at Arkansas City for Pittsburgh lump on board, while Illinois lump from the Big Muddy was delivered on the boats at Grand Tower for 6½ cents the bushel. Making due allowance for the acknowledged inferiority of Illinois coal, the saving would probably not fall much below 25 per cent.

I have but little to suggest in regard to the new tow-boats. In general they should have ample boilers, long-stroke engines with variable cut-off, and, probably, open heaters with circulating coils, and the conventional "doctor" for feeding boilers. Vertical heaters are preferable for the saving in fuel and in the time required for cleaning boilers, but they are objectionable on account of their great size and weight, the difficulty in locating them so that they may be cleaned and drained readily, and lastly from the high pressure required.

The heater put on the Minnetonka, in place of the old one which was worn out, takes the feed-water through a coil into the pan, where it stands at less than 4 inches depth, and delivers it to the boilers at about 206° F. As this arrangement works well, I think it will be best to equip the new boats in the same way, unless it be thought advisable to use independent vertical heaters for each cylinder. For the large boat, four steel boilers, with double steam-drums, and engines 20 inches diameter by 10½ feet stroke, are recommended, and for the small boat three steel boilers, and engines 15 inches diameter by 7 feet stroke. All steam and hot-water pipes and cylinders to be jacketed, and the latter finished with wood lagging.

The upper works should be strong and simple, without ornamentation, and arranged so as to give comfortable accommodations for the crew. For both boats I recommend large hollow shafts of Whitworth compressed steel. As they can be imported free of duty, the cost would probably not exceed that of American iron or steel solid shafts of greater weight for equal strength. The amount asked for the construction of these boats remains the same, but the proportions are changed to $55,000 for the large and $35,000 for the small boat, the estimates being based on the price per pound for the hull of the steel snag-boat now building at Pittsburgh, and from informal offers for machinery, boilers, and upper works from builders in this city.

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Should the plant remain laid up till July, 1886, about $16,800 will be required for docking and general repairs to barges, and for docking the tow-boats, for cleaning, resetting boilers, and minor repairs. I also make an estimate for general and extraordinary repairs for the year, and estimates for running expenses and fuel, on the supposition that active operations will be resumed and that the plant will be suitably increased.

As the conditions were favorable for work during the autumn, heavy demands were made for stone and supplies, especially for the first district. Unfortunately, the low stage of the Ohio prevented getting out much stone from the quarries about Golconda, and scarcity of labor or lack of enterprise retarded the output from the Mississippi quarries. Later in the season stone was taken from quarries as far north as Grafton, all available barges being chartered to expedite the delivery. Contrary to general expectation, severe cold weather set in early, and by December 17 navigation was suspended, leaving the work about half done and the floating property in danger. Considerable stone was lost and a number of barges were sunk, but through the exertions of employés the barges were saved with little damage. The extreme cold prevailed so long that after one or two attempts to deliver tows to the first district the work was given over, and when Congress adjourned without making further appropriations, the floating property was collected and laid up.

All of the stone was purchased in open market at prices ranging from 50 to 60 cents the cubic yard, except for that from the Grafton quarries, which was delivered at Saint Louis for 75 cents, including charter and towing between the quarries and the city. During November and December about 31,000 cubic yards were delivered to the districts, 2,500 yards were lost on the way or thrown overboard to save barges, and about 3,000 yards were afloat at Cairo on the suspension of operations; the latter, not having been paid for, was sold, in order to clear the barges and settle with the parties who furnished it. There remained about 16,000 yards at the quarries ready for loading, most of which was at Chester and Grand Tower. Fair settlements were made with the quarrymen for stone thrown overboard and lost, and the Government freed from liability on account of stone quarried under former agreements. The movement of stone since October 1, 1884, is given in tabular form.

There were three serious losses of property during the season. The chartered barge Morning Star, loaded with about 330 tons of galvanized steel wire, 10 tons of spike, and 87 pieces of dimension timber, for the first district, was sunk in Saladin Channel, October 6. The barge was a total loss, which fell upon owners and insurance company. The cargo was valued at $25,651.71, most of which was saved during the month; the actual value of the property recovered being $24,556, at a cost of $1,727 for wrecking tools and labor.

Chartered barge Missouri No. 4, loaded with stone for the first district, was sunk on a snag near Belmont in November, the loss of the barge falling on the owner.

In the same month general-service barge No. 167, loaded with stone, struck a snag below Cario and sank. An attempt was made to raise it, which proved unsuccessful. Missouri River barge No. 57 was sunk on the way to Plum Point with a load of stone, but was raised and repaired.

November 3 the starboard cylinder-timber of the Minnetonka was found to be broken under the cylinder. The Jack Frost was chartered to take her tow to Lake Providence and fetch the empty barges chartered for the work at New Orleans. The timber was repaired so as to fit her for service temporarily, and has since been replaced by an iron beam.

The expenditures for general service have been apportioned among the districts according to the work done, as computed from the mileage, those for outfit and repairs being divided equally among the first, second, and third. Three hundred and eighty-two pieces have been moved down-stream and 567 pieces up-stream since October 1, the excess of up-stream movement being due to consolidation of the second district plant with that of the first, and towing the general service and Commission fleets to Twin Hollows. The service was equivalent to towing one piece 133,533 miles. The statement of work and apportionment of cost are given in tabular form.

The amount available for general service October 1, 1884, was $291,635.56, of which $97,825.88 have been expended and charged to districts; $58,000 transferred to Lake Providence, and $8,000 to Vicksburg Harbor, Delta Point. The balance available July 1, 1885, is $127,809.68, of which $12,000 will be required for care of property and contingencies to June 30, 1886, and a portion at least should be reserved for putting the plant in running order on resuming operations.

I present herewith directory of the Commission, with its officers and districts under improvement, estimates for general service 1886–'87, statement of plant, statement of general-service mileage, movement of stone, detailed statement of expenditures by the general service, detailed financial statement of all expenditures from October 1, 1884, to June 30, 1885, and a general statement of appropriations and expenditures from March 3, 1881, to June 30, 1885.

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THE MISSISSIPPI RIVER COMMISSION.

Col. and Bvt. Maj. Gen. QUINCY A. GILLMORE, Corps of Engineers, president, 33 West Houston street, New York.

Lieut. Col. and Bvt. Brig. Gen. CYRUS B. COMSTOCK, Corps of Engineers, 33 West Houston street, New York.

Maj. CHARLES R. SUTER, Corps of Engineers, 1415 Washington avenue, Saint Louis.

HENRY MITCHELL, civil engineer, United States Coast and Geodetic Survey, 9 Pemberton square, Boston.

B. M. HARROD, civil engineer, Cotton Exchange Building, New Orleans.

S. W. FERGUSON, civil engineer, Greenville, Miss.

Hon. ROBERT S. TAYLOR, post-office box 1648, Fort Wayne Ind.

Capt. THOMAS TURTLE, Corps of Engineers, secretary, 2828 Washington avenue, Saint Louis.

THE COMMITTEE ON CONSTRUCTION.

Messrs. GILLMORE, COMSTOCK, SUTER, and HARROD.

Capt. JOSEPH H. WILLARD, Corps of Engineers, secretary and assistant, 2653 Olive street, Saint Louis.

OFFICERS OF CORPS OF ENGINEERS IN CHARGE OF DISTRICTS.

Des Moines Rapids to Illinois River, 165 *miles.*

Capt. ERNEST H. RUFFNER, Quincy, Ill.

Illinois River to Ohio River, 245 *miles.*

Maj. OSWALD H. ERNST, custom-house, Saint Louis.

First district, Ohio River to foot of Island No. 40 (*Plum Point Reach*), 220 *miles.*

Capt. SMITH S. LEACH, custom-house, Cairo, Ill., and Elmot, Ark.

Second district, foot of Island No. 40 *to White River* (*Memphis Reach*), 180 *miles.*

Capt. SMITH S. LEACH, 280 Front street, Memphis, Tenn.

Third district, White River to Warrenton, Miss. (*Lake Providence Reach*), 220 *miles.*

Capt. CLINTON B. SEARS, 106 Madison street, Memphis, Tenn., and Wilson's Point, La.

Fourth district, Warrenton to Head of Passes, 484 *miles.*

Maj. AMOS STICKNEY, 3 South Rampart street, New Orleans.

General service estimates, 1886–'87.

One large steel tow-boat	$55,000		
One small steel tow-boat	35,000		
		$90,000	
11 coal-barges		22,000	
12 small gunwale barges		24,000	
32 large gunwale barges		96,000	
			$232,000
General repairs to plant on resuming operations		16,800	
General and extraordinary repairs during year		9,000	
			25,800
			257,800
Running expenses of tow-boats:			
Mississippi, eight months, at $3,400		27,200	
Minnetonka, ten months, at $3,600		36,000	
New large tow-boat, three months, at $3,600		10,800	
New small tow-boat, three months, at $2,400		7,200	
		81,200	
500,000 bushels Illinois coal, on board, at 8 cents		40,000	
			121,200
Office salaries, rent, and contingencies		12,000	
Administration and inspection		5,000	
Fleet and care of property		4,000	
			21,000
			$400,000

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Approximate value of plant belonging to the United States and used upon the improvemen of the Mississippi River, general service.

Class of property.	Approximate value June 30, 1885.
1 steamer, Mississippi	$60,000
1 steamer, Minnetonka	40,000
1 pump-boat	1,000
1 store-boat	500
2 sounding-boats	40
1 yaul	40
28 barges (flush deck)	33,600
28 barges (low deck)	50,400
Office furniture	400
Total value	185,980

Statement of mileage of general-service tow-boats from October 1, 1884, to June 30, 1885.

Tow-boat.	For first district.	For second district.	For third district.	For general service.	Total.
Mississippi	23,274	12,006	7,621	8,781	51,682
Minnetonka	19,599	26,496	4,207	5,954	56,256
Pearl	15,296	1,101	526	825	17,748
Jack Frost	.....	.....	7,847	.....	7,847
	58,169	39,603	20,201	15,560	133,533

Movement of stone from October 1, 1884 to June 30, 1885.

At fleet and in tow, October 1, 1884 ..... cubic yards	8,178		
From Mississippi quarries ..... do	32,001		
From Ohio quarries ..... do	13,069		
			53,248
Delivered to first district ..... do	23,026		
Delivered to second district ..... do	13,395		
Delivered to third district ..... do	5,015		
Delivered to fourth district ..... do	4,392		
		45,828	
Lost at quarries, fleet, and in tow ..... do	4,165		
Sold ..... do	3,255		
		7,420	
			53,248

Expenditures by Capt. J. H. Willard, secretary committee on construction, Mississippi River Commission, on account appropriation for Improving Mississippi River, no limit, from allotment for general service, from October 1, 1884, to June 30, 1885.

Plant and outfit	$3,719 09
Repairs to plant	19,278 71
Care of public property	6,351 14
Administration and inspection	2,132 30
Office expenses, rent, and repairs	7,877 45
Barge charter	1,334 00
Running expenses steamer Mississippi	18,537 99
Running expenses steamer Minnetonka	14,708 01
Running expenses steamer Pearl	11,840 91
Running expenses steamer Jack Frost	5,620 63
Stone lost by sinking	2,103 60
Raising sunken barges	3,123 30
Towage	795 35
United States Marine Hospital Service	403 40
Total	$97,825 88

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The above expenditures apportioned as follows:

To first district	$44,303 85
To second district	30,503 67
To third district	21,657 75
To fourth district	1,360 61
Total	$97,825 88

FINANCIAL STATEMENT.

October 1, 1884, to June 30, 1885.

General service.

Available October 1, 1884		$291,635 56
Transferred to Lake Providence	$58,000 00	
Transferred to Delta Point	8,000 00	
Expended account Plum Point Reach	44,303 85	
Expended account Memphis Reach	30,503 67	
Expended account Lake Providence Reach	21,657 75	
Expended account New Orleans Harbor	1,360 61	
		163,825 88
Balance in Treasury	70,000 00	
Balance in hand	57,809 68	
		127,809 68

Des Moines Rapids to Illinois River.

Available October 1, 1884		181,748 65
Transferred to snag-boat service		5,000 00
Balance		176,748 65
Received from sale of fuel		43 89
Total		176,792 54
Expended		90,034 49
Balance in Treasury	$65,000,00	
Balance in hand	21,758 05	
		86,758 05

Illinois River to Ohio River and protection of the easterly bank of the Mississippi near Cairo.

Available October 1, 1884		$459,109 58
Received from sale of fuel		70 43
Total		429,180 01
Expended, Illinois River to Ohio River	$323,888 90	
Expended, Cairo	22,431 08	
		346,319 98
Balance in Treasury	75,000 00	
Balance in hand	37,860 03	
		112,860 03

New Madrid Reach.

Available October 1, 1884	2,141 09
Expended	3 00
Balance in hand	2,138 08

Plum Point Reach.

Available October 1, 1884	320,243 88
Drawn from Treasury for general service	44,303 85
Total	364,547 73
Expended	348,042 62
Balance in Treasury	$11,520 00
Balance in hand	4,985 11
	16,505 11

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Saint Francis Front—First District.

Available October 1, 1884	$126 89
Expended	0 00
Balance in hand	126 89

Memphis Reach.

Available October 1, 1884	55,626 09
Drawn from Treasury for general service	30,503 67
Received from sale of fuel	11 25
Total	86,141 01
Expended	86,071 77
Balance in hand	69 24

Memphis Harbor.

Available October 1, 1884	129,211 87
Received from sale of fuel	22 50
Total	129,234 37
Expended	127,792 84
Balance in hand	1,441 53

Saint Francis Front—Second District.

Allotment expended before October 1, 1884.

Survey of Helena Reach.

Allotment expended before October 1, 1884.

Lake Providence Reach.

Available October 1, 1884	$263,492 67
Drawn from Treasury for general service	21,657 75
Transferred from general service	58,000 00
Transferred from Tensas Front	7,700 00
Transferred from Yazoo Front	2,000 00
Transferred from Choctaw Bend	1,320 14
Received from sale of fuel	31 50
Total	354,202 06
Expended	332,131 61
Balance in hand	22,070 45

Vicksburg Harbor (dredging).

Allotment expended before October 1, 1884.

Vicksburg Harbor (Delta Point).

Available October 1, 1884	$10,720 69
Transferred from unallotted reserve	4,000 00
Transferred from general service	8,000 00
Total	22,720 69
Expended	19,037 81
Balance in hand	3,682 88

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Survey of unleveed fronts—Third District.

Available October 1, 1884	51
Expended	51
Balance in hand	00

Choctaw Bend survey.

Available October 1, 1884	1,320 14
Transferred to Lake Providence	1,320 14
Balance in hand	0 00

New Orleans Harbor.

Available October 1, 1884	$45,403 07	
Reverted to Treasury	123 42	
		45,279 65
Transferred from Red River		900 00
Drawn from Treasury for general service		1,360 61
Total		47,540 26
Expended		46,943 69
Balance in hand		596 57

Mouth of Red River.

Available October 1, 1884	22,499 42
Transferred to New Orleans Harbor	900 00
Balance	21,599 42
Expended	17,783 34
Balance in hand	3,816 08

Natchez and Vidalia.

Available October 1, 1884	2,672 92
Expended	1,046 97
Balance in hand	1,625 95

Observations at Carrollton.

Allotment expended before October 1, 1884.

Survey of unleveed fronts—Fourth District.

Available October 1, 1884	$97 88
Expended	97 88
Balance	0 00

Survey of Cubitt's Gap.

Available October 1, 1884	162 86
Expended	0 00
Balance in hand	162. 86

Levees—Second District.

Yazoo Front.—Allotment expended before October 1, 1884.

Long Lake:

Available October 1, 1884	14,984 45
Expended	14,984 45
Balance	0 00

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Levees—Third District.

Tensas Front:	
Available October 1, 1884	57,186 47
Transferred to Lake Providence	7,700 00
Balance	49,486 47
Expended	49,454 21
Balance in hand	32 26
Yazoo Front:	
Available October 1, 1884	23,594 25
Transferred to Lake Providence	2,000 00
Balance	21,594 25
Expended	21,419 70
Balance in hand	174 55
Opossum Fork:	
Available October 1, 1884	25,000 00
Expended	25,000 00
Balance	0 00

Levees—Fourth District.

Atchafalaya Front:	
Available October 1, 1884	19,091 60
Transferred to Tensas Front	3,000 00
Balance	16,091 60
Expended	6,595 53
Balance in hand	9,496 07
Tensas Front:	
Available October 1, 1884	92,973 37
Transferred from Atchafalaya Front	3,000 00
Transferred from unallotted reserve	8,710 00
Total	104,683 37
Expended	104,071 61
Balance in hand	611 76
Total available October 1, 1884 (levees)	232,830 14
Transferred from unallotted reserve	8,710 00
Total	241,540 14
Transferred to Lake Providence	9,700 00
Balance	231,840 14
Expended	221,525 50
Balance in hand	10,314 64
Total available October 1, 1884, for Improving Mississippi River	2,031,753 91
Reverted to Treasury $123 42	
Transferred to snag-boat service 5,000 00	
	5,123 42
Balance	2,026,630 49
Received from sale of fuel	179 57
Total	2,026,810 06
Expended	1,636,832 01
Balance available July 1, 1885, to meet liabilities and to carry on work under the Mississippi River Commission	389,978 05

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Statement of funds available for Improving Mississippi River, from March 3, 1881, to June 30, 1885.

Act of March 3, 1881		$1,000,000 00
Act of August 2, 1882		4,123,000 00
Act of January 19, 1884		1,000,000 00
Act of July 5, 1884, less $5,000 transferred to snag-boat service		2,065,000 00
Total specific appropriations		8,188,000 00
Balances from former appropriations applied to works below Cairo, under act of August 2, 1882, less $123.42 reverted to Treasury	$272,504 96	
Same for works above Cairo, under act of July 5, 1884	22,632 53	
Total balances		295,137 49
Received from sale of fuel and loss of property		411 07
Total available		8,483,548 56
Expended to June 30, 1885		8,093,570 51
Balance available July 1, 1885		389,978 05

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Detailed statement of funds applied to Improving Mississippi River, under the Mississippi River Commission, from March 3, 1881, to June 30, 1885.

Districts.	From appropriations.	From balances.	From sales.	Total available.	Expended.	Balances in Treasury.	Balances in hand.	Total balances.
Des Moines Rapids to Illinois River	$195,000 00	$12,663 38	$43 89	$207,707 27	$120,949 22	$65,000 00	$21,758 05	$86,758 05
Illinois River to Ohio River	470,000 00	9,969 15	70 43	480,039 58	389,339 56	75,000 00	15,700 02	90,700 02
Protection near Cairo	50,000 00			50,000 00	27,839 99		22,160 01	22,160 01
	520,000 00	9,969 15	70 43	530,039 58	417,179 55	75,000 00	37,860 03	112,860 03
Survey Saint Francis Front	5,000 00			5,000 00	4,873 11		126 89	126 89
New Madrid Reach	212,500 00		2 83	212,502 83	210,364 74		2,138 09	2,138 09
Plum Point Reach	2,395,424 53		99 70	2,395,524 23	2,379,019 12	11,520 00	4,985 11	16,505 11
Totals First District	2,612,924 53		102 53	2,613,027 06	2,594,256 97	11,520 00	7,250 09	18,770 09
Survey Saint Francis Front	4,000 00			4,000 00	4,000 00			
Survey Helena Reach	8,000 00			8,000 00	8,000 00			
Levees—Long Lake	15,000 00			15,000 00	15,000 00			
Levees—Yazoo Front	80,950 00			80,950 00	80,950 00			
Memphis Harbor	200,000 00		22 50	200,022 50	198,580 97		1,441 53	1,441 53
Memphis Reach	477,121 81		20 47	477,142 28	477,073 04		69 24	69 24
Totals Second District	785,071 81		42 97	785,114 78	783,604 01		1,510 77	1,510 77
Survey unleveed fronts	1,000 00			1,000 00	1,000 00			
Survey Choctaw Reach	2,679 86			2,679 86	2,679 86			
Levees—Opossum Fork	25,000 00			25,000 00	25,000 00			
Levees—Yazoo Front	365,050 00			365,050 00	364,875 45		174 55	174 55
Levees—Tensas Front	411,140 00			411,140 00	411,107 74		32 26	32 26
Vicksburg Harbor—dredging	61,812 12			61,812 12	61,812 12			
Vicksburg Harbor—Delta Point	93,486 46	25,770 13		119,256 59	115,573 71		3,682 88	3,682 88
Lake Providence Reach	2,262,216 18		140 00	2,262,356 18	2,240,285 73		22,070 45	22,070 45
Totals Third District	3,222,384 62	25,770 13	140 00	3,248,294 75	3,222,334 61		25,960 14	25,960 14
Survey Cubitt's Gap	300 00			300 00	137 14		162 86	162 86
Survey unleveed fronts	1,000 00			1,000 00	1,000 00			
Observations at Carrollton	3,000 00			3,000 00	3,000 00			
Bonnet Carré Crevasse	15,000 00			15,000 00	15,000 00			
Natchez and Vidalia harbors		8,252 04		8,252 04	6,626 09		1,625 95	1,625 95

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Detailed statement of funds applied to Improving Mississippi River, under the Mississippi River Commission, &c.—Continued.

Districts.	From appropriations.	From balances.	From sales.	Total available.	Expended.	Balances in Treasury.	Balances in hand.	Total balances.
New Orleans Harbor	$2,260 61	$147,670 39	.....	$149,931 00	$149,334 43	.....	$596 57	$596 57
Mouth of Red River	11,390 00	90,812 40	.....	102,202 40	98,386 32	.....	3,816 08	3,816 08
Levees—Tensas Front	548,870 00	.....	.....	548,870 00	548,258 24	.....	611 76	611 76
Levees—Atchafalaya Front	143,000 00	.....	.....	143,000 00	133,503 93	.....	9,496 07	9,496 07
Totals Fourth District	724,820 61	246,734 83	.....	971,555 44	955,246 15	.....	16,309 9	16,309 29
General service	127,798 43	.....	$11 25	127,809 68	.....	$70,000 00	57,809 68	127,809 68
Grand totals	8,188,000 00	295,137 49	411 07	8,483,548 56	8,093,570 51	221,520 00	168,458 05	389,978 05

Respectfully submitted.

J. H. WILLARD,
Captain of Engineers, Secretary Committee on Construction.

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APPENDIX E.

REPORT OF CAPTAIN E. H. RUFFNER, CORPS OF ENGINEERS, UPON THE IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE DES MOINES RAPIDS AND THE MOUTH OF THE ILLINOIS RIVER.

UNITED STATES ENGINEER OFFICE,
Quincy, Ill., June 17, 1885.

SIR: I have the honor to render the following report of operations on the improvement of the Mississippi River from the Des Moines Rapids to the mouth of the Illinois River, for the interval October 1, 1884, to June 30, 1885:

UNITED STATES DREDGE-PLANT.

This plant, consisting of the tow-boats Nos. 3 and 4, dredge No. 2, launch, and barges, the whole under charge of Assistant Engineer W. A. Thompson, operated between Canton and Quincy.

The fence-dam previously built between Island 420 and the Illinois shore, opposite La Grange, had been damaged by the passage through it of a raft, and was repaired.

This dam, at the close of the year 1884, consumed materials at prices and in amounts as follows:

[Fence-dam, Island 420, 1,000 feet long; shore protections, 400 feet.]

Materials, &c.	Quantity.	Cost.	Average cost.	Remarks.
Gravel.....cubic yards..	12,133	$1,337 57	$0.102	Dredged and deposited on dam.
Do.....do ...	5,444	1,254 30	.23	Dredged and shoveled on dam.
Stone and brush.....do....	2,645	2,176 68	.823	
Bulkhead.....feet...	835	454 07	.....	
Frame.....do....	1,388		.....	
Piles.....do....	2,268		.....	
Total.....	.....	5,222 62	.....	

This dam was injured by the ice in the spring of 1885, and was repaired by day labor and the use of Government plant, the stone being procured by public notice and sealed proposals at the following rates (all other materials are also included):

Materials, &c.	Cubic yards.	Average cost.	Amount.
Stone	2,044.90	$0.70	$1,431 43
Brush	*540	.....	.....
Do	†260.79	.....	.....
Subsistence	.....	.....	219 31
Labor	.....	.....	618 34
Launch	.....	.....	212 67
Sundries	.....	.....	29 13
Total	.....	.....	2,510 88

*On hand. †Cut.

Which, added to prior sum, gives a total of $7,632.50, or an average cost per running foot of $5.45.

A short closing-dam, 325 feet long, 400 feet shore-protection, between islands 419 and 418, was built in October. Stone and brush, 2,816.39 cubic yards, cost $2,824.61, or an average cost per running foot of $3.90.

A wing-dam, known as 4.66, begun in September, 1884, and located just above the head of Island 419, is 1,200 feet long, with a T head 175 feet long, and has 200 feet shore-protection. The dam is built on gravel foundation, and was raised to a height of 4 feet above low-water mark; completed November 6, 1884.

Materials, &c.	Cubic yards.	Total cost.	Average per yard.
			Cents.
Stone and brush	7,293	$6,974 49	95.6
Gravel	16,095	1,834 83	11.4
Bulkhead	.....	293 16	.....
Total cost	.....	$9,102 48	.....

Average cost per running foot, $5.15.

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To facilitate the scouring action of the two dams, spurs from Island 418, the dredge cut a channel, in November, through Wyaconda Bar, finishing November 25; length 1,500 feet, width 50 feet, depth 8 feet; cost as follows: 7,813 cubic yards; cost, $851.57; average, 10.89 cents. November 7 to 29 was employed in building shore-protection, 2,100 feet long, on west side small island at mouth of Quincy Bay.

Stone and brush, 4,133 cubic yards; cost, $3,642.33; average, 88.12 cents; average cost per running foot, $1.73.

This fleet laid up November 29. The dredge did not work continuously, partly owing to high water, partly to breakages. The dredge has been put in thorough repair during the winter, but has not been in operation this spring.

Some repairs have been necessary to the brush fence-dam from Island 427 to the Missouri shore, in October:

Stone	cubic yards ..	492
Brush	do	75
Piles		20

Besides a small break repaired in one day in April. Total cost of these repairs, $1,049.66, not easily divided into items.

Dredging in Quincy Bay has continued during the fall and spring under the contract with H. S. Brown, reported last year. A channel 2,900 feet long and 100 feet wide at the bottom has been cut through the bar at the mouth of Whipple's Creek; and a cut has been made to the mouth of the creek, so as to divert therein its waters, in order to preserve the channel across the bar. Special areas in the bay have been dredged where necessary, and a large amount of the bar removed directly, without reference to channels; 68,204.7 cubic yards in all have been dredged, at a total cost of $9,548.65, including retained payments. This dredging will be continued until the amount of the contract, $12,500, is exhausted. Mr. George Waters is acting as inspector.

BROKAU ISLAND DAM.

The contract made September 24 with Patterson Brothers, as already reported, for the construction of a closing-dam between Island 458, "Brokau" Island, and the Illinois shore, was carried to completion. It was about three-fourths finished in 1884, and completed in 1885. This dam rests upon a gravel foundation, and above that is of the usual brush and stone construction. Its cost and material account is as follows:

Materials.	Cubic yards.	Total cost.	Average cost.
Gravel	19,760	$4,940 00	$0 25
Piling		60 00	
Stone	11,882.22	16,041 00	1 35
Brush	8,445.25	5,489 41	65
Total		26,530 41	

Total length of dam 1,200 feet and shore protection 1,750 feet. Average cost of the whole per running foot, $8.93. During construction this dam suffered a serious break in the spring of 1885. The expenses of inspection have not been included above. Messrs. J. C. McElherne, A. W. Buel, and C. M. Bennett, have acted as inspectors at different times on this work. Final work done and contract completed in May.

UNITED STATES TOW-BOAT NO. 5, AND PLANT.

This plant, the steamer Coal Bluff, was in charge of Overseer C. M. Bennett, and on October 1, 1884, was engaged in building dam between Bolter's Island No. 515, and its tow-head. This dam 375 feet long with 400 feet shore protection, besides 850 feet shore protection on the tow-head itself, was finished in October.

Repairs were also made at the same time to the dam running from Island 514 to Island 515, and also that from Island 514, Dardenne Island, to Islands 513 and 512, known as Dardenne Dam.

These works consumed materials as follows:

Materials.	Cubic yards.	Total cost.	Average cost.
Stone	5,476	$7,664	$1.016
Brush	2,063		

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A break in the Hannibal Dam, 250 feet in length, and 8 feet in depth, from the shore out, was repaired, together with other smaller breaks further out.

Material account.

Materials.	Cubic yards.	Total cost.	Average cost.
Stone	2,418	$3,359	$1 10
Brush	653		

A bad break in Denmark Dam, from Island 450 to the Illinois shore, was repaired in November. This break extended from the Illinois shore to within 200 feet of Denmark Island, and was brought to a height of 7 feet above low water, except on a part of the line. Advent of cold weather forced a suspension before completion.

Material account.

Materials.	Cubic yards.	Total cost.	Average cost.
Stone	4,515	$6,089 05	$1 09
Brush	1,081		

These items do not include the expenses of the steamer which when apportioned to the whole, and the entire amount of material handled during the season is considered, gives an average of $1.056 per cubic yard for putting in place 16,201 cubic yards of material.

The fleet went into winter-quarters in Quincy Bay November 27. The Coal Bluff needing extensive repairs, advertisement was made in December for proposals to do the principal carpenter work. No bids were received, however, and the work was done by hired labor during the winter and spring.

Bids were opened, after due advertisement, on February 19, for new boilers for the Coal Bluff, and the contract awarded to the Iowa Iron Works Company, Dubuque, Iowa, for $2,095. The boilers are in place, and the boat ready for use. Total cost of repairs, $5,371.61.

During the season of 1884 work was impeded by lack of barges, and one was bought, and bids asked for five new ones, for the future. Bids were opened December 10, and the contract awarded to J. R. Morgan & Son, Clinton, Iowa. These barges have been built and delivered at a cost of $7,500, besides the expenses of inspection. Two new quarter-boats, under contract in the fall, were received, at a cost of $830. The entire plant has been put in good order, and is ready for use.

SURVEYS.

Surveys were made during the fall by Inspector J. C. McElherne:

I. At the foot, and for a mile up Hamburg Bay, over bars which now impede navigation.

II. At Cap au Gris, where numerous islands divide the river into channels, none of them deep or permanent.

III. From the head of Bolter's Island to the foot of Island 522.

These surveys were intended to base new work upon. At Whitney's Bar, above Hannibal Bridge, surveys made early as 1884, by Assistant Engineer Chaffee, have been platted. This is with reference to future work.

An edition of the maps of the survey of 1878, of this part of the river, was prepared for photolithographing and forwarded for reproduction.

These maps are for general use and to accompany reports.

In March, Overseer Bennett and Inspector McElherne made a survey of the bar at the mouth of Whipple Creek, in Quincy Bay, in order to base the further work under the dredging contract there. This has been platted. These gentlemen afterwards made surveys in front of Quincy and at Brokau Island, to determine the effect of recent constructions at these places. No decided changes are reported, and the plats show a gradual but not marked improvement. In April, Inspector McElherne made a survey of 3 miles to cover Wyaconda and Howard's bars above La Grange to ascertain the effect of last year's work; not platted yet, and in June Messrs. Bennett and McElherne, surveyed for 9 miles above Island 413, to base future work upon; and made one of 3 miles opposite Cincinnati Landing and Gilbert's Island, to determine amount of work needed there. These last surveys are not platted.

Financial statement in detail to cover period from July 1, 1884, to June 30, 1885, is given, and the estimate of the value of plant.

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An allotment of $5,000 was made by the Secretary of War, towards meeting the expenses of the snag-boat, operating the Upper Mississippi River. No operations are proposed until extreme low water, when urgent demands will be met if possible, and temporary channels made where required.

Very respectfully, your obedient servant,

E. H. RUFFNER,
Captain of Engineers.

Col. QUINCY A. GILLMORE,
Corps of Engineers, President Mississippi River Commission.

FINANCIAL STATEMENT.

Appropriation July 5, 1884		$200,000 00
Received from Captain Ruffner, sale of fuel		43 89
Total		$200,043 89
Expended by Major Mackenzie	$9,513 61	
Rxpended by Captain Ruffner, to October 1, 1884	8,737 74	
Expended by Captain Ruffner, October 1, 1884, to June 30, 1885:		
Care and maintenance of plant	4,436 14	
Dams between Canton and La Grange	11,910 19	
Dredging in Quincy Bay	8,593 79	
Louisiana Brokau Island Dam	25,933 81	
Operations Coal Bluff and barges	3,137 97	
Office expenses	5,471 52	
Plant	9,882 48	
Quincy shore protection	4,313 28	
Repairs to Brush Fence Dam	1,049 66	
Repairs to Hannibal Dam	2,192 07	
Repairs of Denmark Dam	6,125 48	
Repairs to steamer Coal Bluff, including new boilers	5,371 61	
Survey account	3,155 59	
Gauge account	27 00	
Total expenditures	109,851 94	
Balance on contract, H. S. Brown	3,906 21	
Allotted for continuing snagging operations, Upper Mississippi River	5,000 00	
		118,758 15
Balance available June 30, 1885		$81,285 74

Approximate value of plant belonging to the United States and used upon the improvement of Mississippi River from Des Moines Rapids to mouth of Illinois River—Illinois and Missouri.

Class of property.	Approximate value, June 30, 1885.
Steamer Coal Bluff	$15,000 00
Launch Irene	1,500 00
6 model barges, at $2,700	16,200 00
3 model barges (Nos. 48, 49, and 51), at $1,000	3,000 00
1 old barge (No. 53)	300 00
1 coal flat	1,000 00
5 new flats, at $1,500	7,500 00
1 new flat	1,100 00
1 pile-driver and tender	1,600 00
1 dredge	22,500 00
6 dump-boats, at $900	5,400 00
1 quarter-boat	1,000 00
2 quarter-boats, at $400	800 00
2 quarter-boats, worthless	
8 skiffs, at $15	120 00
Tools and appliances	800 00
Surveying instruments	850 00
Office furniture	200 00
Total	$78,870 0

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APPENDIX F.

REPORT OF MAJOR O. H. ERNST, CORPS OF ENGINEERS, UPON THE IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., June 18, 1885.

COLONEL: In compliance with the instructions contained in your letter of the 1st instant, to "prepare a brief report of operations in the district under your [my] charge from the date at which the last annual report leaves them, to June 30, 1885," I have the honor to submit the following:

My last annual report brought the history of the works down to October 1, 1884. At that date operations were in progress at Horsetail, Twin Hollows, Pulltight, Jim Smith's, and Cairo, and had been begun at Alton, but at that locality were temporarily suspended on account of high water. In addition to continuing these works, some work has been done at Arsenal Island and Cahokia Chute, and Chesley Island. All of these except Alton and Cairo form part of the continuous series of works just below Saint Louis.

ALTON.

The work of filling up the depressions in the dike opposite and above the city, and of raising the general level of its crest, was resumed November 1, and continued to December 3, when it was suspended. The quantity of material placed was 5,253 cubic yards riprap. The dike was completed to its full height of 14 feet above standard low water over a distance of 4,000 feet, measured from its shore end. The remaining portion of the dike, 800 feet in length, is left at a lower level. The good results at the Alton landing previously reported have been maintained. No further work is required here for the present.

ARSENAL ISLAND AND CAHOKIA CHUTE.

The revetment at the head of Arsenal Island was completed this spring by being carried up to the top of the bank for a distance of 675 feet on the west side and 355 feet on the east side, both measured from the up-stream point of the island. A temporary protection, consisting of a mattress 40 feet wide, was also placed on the east side, extending from the end of the permanent protection to Hurdle No. 2, across Cahokia Chute. Some small repairs were made in Hurdles Nos. 1 and 2, across Cahokia Chute. Heavy additional deposits have been secured in the chute. The least depth of channel found in this vicinity since my last report was 12 feet.

HORSETAIL.

In continuing the protection of the new bank on the west side the revetment was carried up to a height of from 16 to 21 feet above standard low water for a length of 2,140 feet and to a height of 11 feet for a length of 620 feet. The total length of this revetment is 3,910 feet over which distance all erosion has been stopped.

Upon the Illinois side Hurdles Nos. 27½ and 29½, which were nearly finished at the date of my last report, were completed and No. 31, which had just been begun, was built to its full length of 2,675 feet. A new hurdle, No. 32, was laid out about 1,000 feet below No. 31, and was built to its full length of 2,775 feet. Nos. 31 and 32 were completed except that for a length of 800 feet at the outer end of No. 31 and 300 feet at the outer end of No. 32 the wattling was not carried to the tops of the piles but was left at a level 8 feet above standard low water. This was done in accordance with my regular practice not to bring too heavy a strain upon the hurdles at first in deep water. The wattling will be continued to full height after the hurdles shall have been reinforced by deposits. Some extensive repairs were found necessary in the Carroll's Island hurdle, which were made. Heavy additional deposits have been secured on both sides of the river. The least depth of channel found in the Horsetail Reach since my last report was 9 feet.

TWIN HOLLOWS, WEST SIDE.

The repairs in the primary hurdle and in secondary Nos. 4 and 5 were completed The construction of an additional hurdle, to be called No. 6, had been contemplated, but the idea was abandoned for the present, when Congress adjourned without renewing the appropriations. Large additional deposits have been secured here. The least depth of channel found in this vicinity since my last report was 8¼ feet.

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TWIN HOLLOWS, EAST SIDE.

The extension down-stream of the revetment at this place was continued. The mattress, 120 feet wide, to be placed below low-water mark, which at the date of my last report had reached a length of 990 feet, was extended 1,835 feet, making its total length 2,825 feet. Being thus connected with the head of the Pulltight work, it was cut loose from the ways and sunk. Riprap was deposited upon the bank above low-water mark, raising the revetment to higher levels at various parts of the old and new work, where the bank had been graded to a proper slope by the action of the river.

From Station 22 to Station 47, and from 76 to 81, it was raised to a height 16 feet above standard low water, and from Station 87 + 50 to Station 93 + 75 to a height 10 feet above the same plane. The total length of this revetment is 11,400 feet. Some portions of it, particularly at the down-stream end, will be raised to higher levels in the future as the upper bank takes a proper slope. All of it stands intact.

PULLTIGHT.

The construction of Hurdle No. 4, which was progressing at the date of my last report, was completed. A new hurdle, called No. 3, was laid out about 1,300 feet below No. 2, and built out to a distance of 550 feet from shore, where it connected with a high bar. Some repairs were made in Nos. 1 and 2 and in the primary hurdle. Large additional deposits have been secured among the hurdles.

CHESLEY ISLAND.

The revetment placed in former years at Chesley Island stands intact. It was thought desirable, however, to raise the level of the portion of it near the head of the island to the full height of the bank. This was done for a distance of 590 feet on the east side and 410 feet on the west side. The hurdle in the chute west of the island remains in bad condition. The reduction of force made necessary by the failure of the river and harbor bill at the last session of Congress has rendered it impracticable to repair it this spring, as was contemplated. It is expected that that can be done during the coming year with funds now available.

JIM SMITH'S.

The primary hurdle was repaired and reinforced for a length of 1,600 feet from shore, where it terminated, and the thirteen secondary hurdles contemplated in the project were practically completed. No. 1 is 1,050 feet long; No. 2, 1,640 feet; No. 2½, 2,010 feet; No. 3, 1,800 feet; No. 3½, 1,525 feet; No. 4. 1,300 feet; No. 4½, 1,170 feet; No. 5, 1,070 feet; No. 5½, 1,115 feet; No. 6, 890 feet; No. 6½, 780 feet; No. 7, 890 feet; No. 7½, 1,050 feet. Nos. 3½ and 5½ were slightly damaged by ice during the winter, and were repaired; Nos. 1, 2, 2½, 3, 3½, 4, 4½, 5, and 5½ were completed to their full length. Nos. 6, 6½, 7, and 7½ extend from shore to a high bar near the proposed new shore-line. A heavy rise in the river brought the work to a close about the middle of June. At that time the hurdles were all completed for the lengths above given, except that the wattling had not been placed for a length of about 125 feet at the outer end of No. 2½, and for a length of about 60 feet near the shore-end of each of Nos. 6, 6½, 7, and 7½. Large deposits have been secured over the area to be reclaimed. The least depth of channel found in this vicinity since my last report was 10½ feet.

CAIRO.

The mattress, 120 feet wide, to be placed below low-water mark, which at the date of my last report had reached a length of 1,012 feet, was extended down-stream 3,551 feet, making its total length 4,563 feet, when, having reached the limit of any threatened undermining of the bank, it was cut loose from the ways and sunk.

Two smaller mattresses, 100 feet by 30 feet, and 120 feet by 40 feet, respectively, were fabricated and placed between the fifth and sixth of the old spur-dikes. The old protection placed by the Cairo Land Company above the water-surface was re-enforced and repaired wherever it seemed necessary by the deposit of riprap. About 45,556 square feet of surface, extending over 1,158 linear feet of the bank, was covered with stone. Near the down-stream end of the new mattress the slope of the bank was so abrupt that no stone was placed for a length of 650 feet. The revetment seems now to be in serviceable condition, at least for low and medium stages of the river. The balance of the funds available for this work are being held to await the action of

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high-water upon the upper portions of the bank, and to raise the down-stream portion of the new work to a higher level, as the bank takes a proper slope by the action of the river.

EQUIPMENT.

Thirteen model barges were built under contract by the Paducah Ship-Yard Company, of Paducah, Ky. Barge No. 20 was run into and sunk by one of the Anchor Line boats, and proved a total loss, and five more of the old barge-flats became unserviceable and were sunk.

FINANCIAL STATEMENT.

A financial statement, including a statement of the expenditures at each locality, for the end of the fiscal year, will be forwarded as soon as practicable after the year closes.

Very respectfully, your obedient servant,

O. H. ERNST,
Major of Engineers.

Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

FINANCIAL STATEMENT.

July 1, 1884, amount available		$525,354 51
July 1, 1885, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1884	$412,494 48	
July 1, 1885, outstanding liabilities	6,286 12	
		418,780 60
July 1, 1885, amount available		106,573 91

Submitted in compliance with requirements of section 2 of river and harbor acts of 1866 and 1867.

Statement showing expenditures for construction, &c., for improvement of Mississippi River between mouths of Ohio and Illinois rivers, Illinois and Missouri, for the fiscal year ending June 30, 1885.

For what expended.	Cash.	Material previously purchased.	Plant.	Liabilities accrued.	Total.
Alton Dike	$9,546 74				$9,546 74
Arsenal Island	10,234 18	$377 66	$1,362 41	$78 31	12,052 56
Cahokia Chute	3,370 07	110 36	420 83	16 95	3,918 21
Horsetail, west side	8,979 37	360 45	1,152 04	45 38	10,537 24
Horsetail, east side	67,413 36	2,330 00	8,405 64	421 91	78,570 91
Twin Hollows, west side	19,589 92	775 80	2,519 63	106 20	22,991 55
Twin Hollows, east side	15,510 23	608 24	1,993 66	79 43	18,191 56
Jim Smith's	134,652 43	4,792 04	16,808 96	684 54	156,937 97
Pulltight	31,246 06	1,115 12	3,787 24	157 61	36,306 03
Cairo Protection	28,501 50			81 15	28,582 65
Chesley Island	864 03		50 15		914 18
Thirteen model barges purchased	38,390 60				38,390 60
Pile timber purchased	20,458 08		1,706 50		22,164 58
Non-payment	251 48				251 48
Extraordinary repairs to plant and value of material purchased and on hand	28,171 50				28,171 50
	417,179 55	10,469 67	38,207 06	1,671 48	467,527 76

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Approximate value of plant belonging to the United States and used upon improvement of the Mississippi River between mouths of Illinois and Ohio rivers.

Class of property.	Approximate value June 30, 1885.
1 steamer, A. A. Humphreys	$19,163 45
1 steamer, General Gillmore	18,592 32
1 launch, Florence	700 00
16 barges, model, old	81,959 60
13 barges, model, new	
17 barge-flats	
20 pile-drivers	34,745 44
1 machine shop, floating	1,895 32
1 wharf-boat	141 09
5 quarter-boats	3,775 98
71 skiffs	986 12
48 yawls	1,666 67
119 flats	5,754 02
1 hydraulic excavator	6,773 44
2 ways for mattresses	3,331 69
Tools and appliances	2,513 78
Photographic apparatus	339 51
Office furniture	772 37
Surveying instruments	939 32
Boarding outfit	14,738 29
Total	198,788 41

APPENDIX G.

REPORT OF CAPTAIN SMITH S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FIRST DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 18, 1885.

GENERAL: Pursuant to the instructions contained in your letter of the 1st instant, I have the honor to submit the following report of operations for improving Mississippi River, First District, carried on under the direction of the Commission, from October 1, 1884, the date when its progress was last reported to Congress, to the end of the present month and fiscal year.

I relieved Capt. J. G. D. Knight, Corps of Engineers, of the charge of this district on April 14, 1885, at which date all work had been suspended and the force reduced, both in numbers and salaries, to the lowest practicable basis compatible with the safety of the property.

Among those discharged were the assistants in general charge and all but one of those in local charge of the various constructions. In making up this report I have had to rely entirely on the ten-day reports of the assistants. These are, in the main, formal in style and matter, and enable me to chronicle only the progress of the works and their present condition and results. Whatever these gentlemen may have acquired of that higher experience by which errors are avoided and successes repeated has not been recorded.

As no changes in methods of construction are noted in the reports, the presumption is that standard constructions, fully described in preceding reports, were followed to the close.

Materials and supplies were obtained under contracts made at the beginning of the season, and noted in last report Apart from such contracts, the work was done by hired labor.

GOLD DUST DIKE.

At the date of my last report, October 1, 1884, this system of dikes, consisting of a main or longitudinal dike 2 miles long and seven cross-dikes connecting it with the Tennessee shore, was complete, except a few breaks in the two lower cross-dikes, caused by the high water of January, 1884, and which it had been decided unnecessary to close, and gaps in the main and upper cross-dikes, left for the passage of material. The closure of the latter gaps, with one exception, was in progress and was prosecuted with vigor during the rest of the year. In addition to the new work necessary, the older portions of the main dike were thoroughly gone over and repaired. This portion, built of cottonwood, had been standing over two years, and had greatly

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deteriorated in strength by dry-rot, especially of riders and braces. The latter had been broken down in many cases by drift lodging on the dike, and in many others by rotting off. Numbers of them were broken while drawing the new cables, and a tension below the standard had finally to be adopted. Besides these repairs, the closing of the break of 400 feet in the main dike just below cross-dike No. 3, made in the high water of 1883, was completed.

In addition to the pile-work above described, a mattress partly supplied quillage and foot-mats for the new work, and foot-mat in front of main dike for about 5,000 feet, mainly from No. 2 dike down. Part of this was new work and part a widening of old work deemed too narrow.

The expenditures at this point from October 1, 1884, to April 1, 1885, were $38,230.32 inclusive of pro rata of all miscellaneous and general expenses. Expenditures since April 1 have been exclusively for care of property, and although they must perforce appear as part of the gross cost of the improvement, they are not included in making up the cost per unit of various kinds of work. The plant is being maintained in view of future rather than past work, and the cost of such maintenance should properly be charged to future constructions.

It is difficult to reduce such patchy and miscellaneous work to an arbitrary unit. Captain Knight last year estimated the complete and partial work done here to October 1 as equivalent to 38,974 feet of finished dike, and that necessary to complete the system as equal to 1,400 feet. He gave the cost per linear foot of dike at $15.26, of which $1.40 was for repairs, leaving $13.86 as the cost of new work. Adopting these figures, and completing the record to date, there have been constructed 40,374 feet of dike, costing $15.77 per foot, including $1.91 per foot for renewals and repairs.

On January 11, 1885, a break occurred in the main dike, 300 feet above cross dike No. 3. When first noticed it was 80 feet wide. Within a few days it increased to 250 feet, since when the increase has been little or nothing.* On February 27 a break in main dike 300 feet wide was discovered 400 feet below cross-dike No. 2. This break has not materially enlarged. Both these breaks were thought by the assistant in charge, and apparently with good reason, to have resulted from the weakened condition of the dike, due to rotting of piles and braces. The upper break was precipitated by large masses of ice lodging on the braces as the water fell, and subsequently, after these were broken down, striking the unsupported piles. These two breaks in the main dike, aggregating about 550 feet, have been the only losses sustained by the Gold Dust system during the period covered by this report, so far as could be seen at the lowest stage of water which has occurred.

In general, the deposits within and below this system, since last report, have been constant but slow, as the periods of high water have been short. Locally, great changes have taken place, and of these the fill in the old service channel, closed as above described, may be cited as an example of the astounding results which may be obtained under favorable conditions. This channel, passing through the main dike at its junction with No. 1, was at that point in October last 33 feet deep at low water. It is now dry at 12 or 13 feet above low water, giving a fill of 45 feet obtained in one insignificant rise. This channel is closed to No. 2 dike. Its closure below that point was prevented by the break in the main dike below No. 2, which sent a supply of water obliquely across to the gap in the shore end of No. 3, and thence down Elmot Chute. There has been cut out in the path of this current a channel which will probably discharge at the lowest stage. Water flowing through the lower break in the main dike also contributes to the discharge of Elmot Chute. No change has been noted in the depth of this chute.

PLUM POINT DIKES.

Of this system, intended in connection with closure of Bullerton Chute and the holding of the tow-head to confine the water in crossing Bullerton Bar, a main and six cross-dikes, aggregating 15,000 feet in length, were in progress at last report and had been completed except some mat-work and wiring, principally on Nos. 5 and 6, and bank protection at the roots of the same dikes.

The work mentioned was practically completed in October and November, though a small party worked on the wiring for some time longer.

The expenditures here from October 1, 1884, to April 1, 1885, were $29,576, and resulted in 15,010 feet of completed dike, at a gross cost of $371,108.36, being $24.72 per linear foot.

Nos. 5 and 6 crossed one of the three low-water channels of the previous season, which they were designed to close. During the run of ice the other channels were nearly closed by a gorge, and the effort of the river against No. 5 was correspondingly increased. It was localized at a point where the tip-mat had not been completed, and

* Since the above was written, report has been received of the widening of this gap to 500 feet.

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on January 4, 185 feet went out, accompanied by a small gap in No. 6 where it crossed the old channel. The gap in No. 5 has increased to about 250 feet, and another one of 50 feet has been made between it and the outer end. About 100 feet of the extreme end have been worn away, making an estimated total of 400 feet of No. 5 lost.

At the outer end of No. 6, and at a point near the middle, a settling of the dike was observed, the whole structure going down about 5 feet, but remaining erect and intact. This appears to be the first occurrence of this phenomenon, and has not as yet been satisfactorily explained.

Considerable deposits within the limits of this system were noticed before the dikes were completed, and their effect since has been marked, although no rise of any considerable duration has passed over them. The last detailed survey in January showed an average fill of 5 feet over the area inclosed and that affected by the dikes. The latter area is included between the Tennessee shore and a line prolonged in the trend of the outer ends of the dikes, as far down as Yankee Bar. Late reconnaissances show the fill to have continued. Within the dikes it averages probably 15 feet. The Yankee Bar low-water channel has nearly or quite filled up despite the breaks in Nos. 5 and 6.

DIKES TO CLOSE BULLERTON CHUTE.

These comprise Osceola No. 4 and Bullerton Nos. 1 and 2.

At last report Osceola No. 4 lacked about 300 feet of completion. The gap was toward the Arkansas shore, where the river had tried to break into Bullerton Chute. A constant draught of water toward the opening brought considerable quantities of drift, which caused much annoyance. Work was greatly impeded by high and at last stopped by low water. The gap was closed, however, the remaining work being in the rear row of piles. It has stood well and answered every purpose of a completed dike. It has collected a large field of drift and caused a heavy fill above and below it. It has been a valuable protection to Bullerton No. 1, and has contributed in no small degree to the closure of Bullerton Chute, which now appears to be an assured fact.

Dikes 1 and 2 in Bullerton Chute work were completed by the construction of work amounting to about 1,000 feet of dike. The openings had been previously mattressed. In driving No. 1 through the deep water and rapid current of the old channel there was a shortage in the supply of long piles, and to avoid bringing the work to a standstill many sticks of insufficient length and strength were used. In this portion a gap of about 100 feet has been made by drift. It is next the Arkansas shore. The mattress prevented any scour at the opening, and the effect of the gap has probably been to accelerate the deposits in the chute by admitting more water, while it has doubtless retarded the deposits in and below the gap in the Osceola–Bullerton dike by increasing the current there. No. 2 is in perfect condition.

The expenditures on these three dikes, including the slight repairs to Osceola No. 3, were $31,919.89.

Bullerton Chute is rapidly filling up. Full half the area between Nos. 1 and 2 is above extreme low water. Two hundred feet below No. 2 the bottom is nowhere more than 8 feet below the same plane.

FLETCHER'S FIELD REVETMENT.

Since October 1, there have been constructed at this point, in continuation of work and project mentioned in last report, 400 feet of mattress and 2,500 feet of upper bank revetment, involving 2,000 feet of grading. At the close of operations the completed revetment covered 5,343 feet of the bank. There was also 1,100 feet of low-water protection without the corresponding upper bank work. The completed work is in three sections. The lowest one, 800 feet long, near Elmot Landing, was put in for local reasons; a very rapid cave at that point threatening the continuity of the curve of the bend. This work is intact and has fulfilled its purpose. The two sections of the systematic work are separated by nearly a mile. This appears to have been skipped in the first instance to await the removal of sunken timber, which required the efforts of one of the large snag-boats for its accomplishment. The Macomb was loaned for the purpose and the bank was cleared, but at a date so near the close of operations that neither the time nor the money was available to close the gap.

The completed work is in perfect condition so far as visible, and there is nothing to suggest any damage to the subaqueous mattress. A loss of 60 feet at the lower end of the lower section has been reported, due to caving working up from below. It is more probable that this 60 feet has fallen down partly around the false point, and has prevented greater loss.

The expenditures chargeable to this work, including the cost of the snag-boat, are $71,442.87.

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REVETMENT OF LOWER OSCEOLA BAR.

Operations at this point comprised the making and sinking of 2,200 feet of mattress and the making of 2,000 feet of complete and 1,200 feet of partial upper bank protection, including 1,500 feet of grading. The close of operations found the bank completely revetted for a distance of 4,500 feet from the head of the bar down, with 700 feet of low water and partial upper bank work below this.

The only injury this work has sustained has been a slide of about 100 feet in length, the middle having gone down about 10 feet and the ends nothing. The cause of this was seepage from ponds left by the falling water. The nearest of these approached within a few yards of the bank, just behind the break, and its water surface was, when first observed, 5 or 6 feet above the river. The sand between the pond and the river was of the consistency of mortar. This pond was drained at a cost of $11, and the sinking was immediately arrested.

Expenditures here were $64,165.88.

REVETMENT OF THE FACE OF BULLERTON TOWHEAD.

This work consisted entirely of repairs to previous work to make good damage caused by seepage. It is noteworthy for the two methods tried, which may be described as a method by draining and a method by bulkheading. The former consists in laying blind drains to dry out the bank as the river falls; the second of a retaining wall of piles and brush built at the outcrops of the water-bearing stratum. Neither has so far failed. The former will be cheaper if found effectual. The assistant retained to care for the property, Mr. A. J. Nolty, had charge of this work. His report is fortunately available for details, and is appended.

The necessity of draining the protected banks has forced itself into consideration through repeated disasters. This appears to be the first serious effort in that direction, and its result is thus far so favorable as to afford strong hope that the last and most insidious enemy of bank revetment will disappear under improved practice.

From the present experience it seems probable that banks of ordinary difficulty can be kept dry with stone drains at a cost of $1 per linear foot.

The expenditures were $19,653.24.

REVETMENT AT CRAIGHEAD POINT.

Work at this point was undertaken in an emergency and under the most unfavorable conditions. The river at a low stage, thrown back from the Bullerton dikes on the one hand and the Plum Point dikes on the other, broke through the bar in a new channel, debouching not more than 1,500 feet from this bank and almost at right angles with it. Violent caving set in and the construction of a mattress in water flowing with a velocity of 7 feet per second was attempted. The results were, unusually large cost of construction and excessive losses during construction. In spite of all difficulties about 1,000 feet of subaqueous mattress and 500 feet of upper-bank protection was in place when a run of ice interrupted, and later exhaustion of funds suspended the work. The subaqueous work seems to have stood, as at the lowest stage its edge was visible at one place, and the caving has been arrested. That it should have done so is entirely beyond reasonable expectation and should not be taken as a precedent for leaving small pieces of work isolated. The little speck of upper-bank work left unprotected on a rapidly caving bank, beset by a violent current, went in at once as a matter of course.

The expenditures at this point were $31,020.

The general condition of the river within the limits of the works remains as at last report, except at Bullerton Bar, where the lower or outside channel of last low water has shifted to a position a little lower down and in prolongation of the ends of the Plum Point dikes. The lower end of the bar which lay off the foot of Bullerton Towhead has followed the crossing down-stream. The bar which formerly joined to the head of Bullerton has been cut through next the towhead, giving about 2 feet less water than the lower way. The crossing from Plum Point to Bullerton Light and between the two described has not changed materially. During a rapid fall of 10 feet in as many days, in the latter part of May, these three routes contested for the honor of the channel. The middle way finally took it with 12 feet at a 12.5 feet stage. The others gave but 8 feet and 10 feet. Such a fall is the most favorable phase for producing obstructions to navigation.

The effects of the different works, as noted in the descriptions of them, do not exactly measure their relative usefulness and value. The Plum Point and Gold Dust system of dikes, for instance, have been laid down on the same plan: that of a main dike run out obliquely from the shore and connected with it by cross-dikes. In development the Plum Point is about 60 per cent. of the Gold Dust system. As regards

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the total volume of deposits secured per foot of dike, the two systems may be equally effective. But the Plum Point system was designed to determine and accelerate the formation of a sand-bar under a partially sheltered point, which should restrict the width of the river at lower stages. The deposits induced by these dikes are producing precisely this effect. The system is but one year old, and should its action continue during the rest of its life, with any approach to its past activity, it cannot fail to produce the effect desired. Hence, for such a situation, such a system of dikes may be taken as perfectly successful, and as forming a precedent for constructions under like conditions. The Gold Dust system was designed to close two side channels formed by two islands, and separated from the main river up to the bank full stage. The deposits have been enormous, but they have not been to any great extent in the chutes. They have thrown a barrier across the upper ends, which late experience has shown will be partially broken down whenever a break in the dikes throws a concentrated volume of water across it. The dikes are now beginning to succumb to age, and the chutes though reduced in size are not closed.

Thus these dikes have been but partially successful, and if the results of the last year were continued during the life of another set, the object aimed at would not be reached. These considerations, taken with the gratifying results obtained on the other side by closing dams, strongly suggest that all closures of *high-water chutes* be made by works of small development and extra strength placed at the lower end. The water bearing the coveted sediment must enter at the upper end, and the portal should be kept broad and inviting to the last moment.

The present standard dike, considered simply as a structure designed to meet certain strains with a maximum of effect at a minimum cost, seems everything that could be desired. In bank protection, by the method of continuous revetment now in use, the great desideratum is that the work shall be complete; that is, that it shall, in one working season, be extended from a point above the cave to a point below it. To leave an end exposed on a bank likely to cave, or leave an unprotected upper bank over a subaqueous protection, is to invite destruction. In cases of absolute necessity the former risk is to be preferred.

Later improvements in this class of work have been principally in the direction of increased longitudinal strength. Recent experience furnishes a number of instances in which such strength has limited to a fault what otherwise would have been a break, which always means a loss. A more thorough system of anchoring to the bank is also desirable. Work of this class on this reach has suffered a very small percentage of loss, despite the fact that it has invariably been done in defiance of the two most important conditions of success—enough money to complete it, and plentiful and timely supplies of material. The one is the principal cause of loss to work in place, and the other of losses during construction. The latter, it may be remarked, needs only a sufficiency of steamers and barges to eliminate it from the problem.

There is submitted herewith a report by Assistant Engineer A. J. Nolty, who had immediate charge of the repairs to Bullerton revetment and the two Bullerton dikes. In order to present all the information attainable, he has, at my suggestions, added his observations of the other works and some data as to their original extent and present condition.

The following financial statement and balance sheet exhibit the financial condition of the district:

APPROPRIATION FOR IMPROVING MISSISSIPPI RIVER, ACT OF JULY 5, 1884, FIRST DISTRICT.

Financial statement.

Balances on hand October 1, 1884, as per last report:		
Plum Point Reach		$320,243 88
New Madrid Reach		2,141 09
Saint Francis Front		126 89
		322,511 86
Expended from October 1, 1884, to June 15, 1885	$299,756 23	
Estimated liabilities to June 30, 1885	5,225 00	
		304,981 23
Balances, June 30, 1885:		
Plum Point Reach	15,265 65	
New Madrid Reach	2,138 09	
Saint Francis Front	126 89	
		17,530 63

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GENERAL BALANCE-SHEET.

Improving Mississippi River, First District, Plum Point Reach.

DR.					CR.
Mar. 3, 1881	To allotment	$568,095 18	Mar. 1, 1884	By expenditures of secretary of Construction Committee from Plum Point allotments, to date	$430,095 1
Aug. 26, 1882	....do	700,000 00			
Apr. 14, 1883	....do	300,000 00			
Sept. 7, 1883	To cash collected	20 00			
Nov. 23, 1883	To allotment (transfer)	10,000 00			
Dec. 10, 1883	To allotment	67,000 00	Apr. 1, 1885	By expenditures of secretary of Construction Committee from allotments for general service, to date	79,049 23
Mar. 4, 1884	To allotment, less subsequent transfers	365,000 00			
Aug. 2, 1884	To allotment	300,000 00			
Apr. 1, 1885	To general service, charges to date	79,049 23	June 15, 1885	By expenditures of district offices, to date, as per voucher books	1,859,529 35
			June 30, 1885	By liabilities	5,225 00
			June 30, 1885	By balance	15,265 65
		2,389,164 41			2,389,164 41

Improving Mississippi River, First District, New Madrid Reach.

DR.					CR.
Aug. 2, 1882	To allotment, less subsequent transfers	$312,500 00	Mar. 31, 1885	By expenditures of district offices, to date	$4,558 69
			Mar. 31, 1885	By expenditures of secretary of Construction Committee, to date	205,803 22
			June 30, 1885	By balance	2,138 09
		212,500 00			212,500 00

Improving Mississippi River, First District, Saint Francis Front.

DR.					CR.
Dec. —, 1882	To allotment	$5,000 00	Apr. 1, 1885	By expenditures of district officers, to date	$4,873 11
			June 30, 1885	By balance	126 89
		5,000 00			5,000 00

There are appended hereto tables of classified expenditur s and value of plant.

Very respectfully, your obedient servant,

MITH S. LEACH,
Captain of Engineers.

General Q. A. GILLMORE,
President Mississippi River Commission.

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Distribution of expenditures on Plum Point Reach, May, 1881, to March 31, 1885.

Locality.	Proportion of general expenses.	Subsistence.	Surveys.	Care of property.	Steamers.	Office and general administration.	Labor on construction.	Construction and outfit of plant.	Material for construction.	Miscellaneous.	Total.
Ashport	109	$2,694 59	$358 95	$1,024 93	$4,333 84	$516 33	$4,989 26	$6,685 73	$5,139 02	$224 00	$25,966 65
Gold Dust	2,673.5	66,090 59	8,802 89	25,134 91	106,282 57	12,663 18	122,353 20	163,950 37	126,023 51	5,453 05	636,754 27
Fletcher's Field	700	17,294 70	2,305 10	6,582 70	27,833 40	3,315 90	32,041 10	42,935 90	33,002 90	1,438 10	166,749 80
Osceola Upper Dike	133	4,771 15	635 56	1,814 78	7,674 07	914 24	8,834 18	11,838 04	9,099 33	396 63	45,977 98
Osceola Middle Dike	194.5	4,808 23	640 51	1,828 88	7,733 71	921 34	8,902 84	11,930 04	9,170 09	399 70	46,335 34
Osceola Cross Dikes, 1, 2, 3, 4	695	17,181 09	2,288 63	6,535 08	27,634 59	3,292 21	31,812 24	42,629 21	32,767 16	1,418 22	165,558 43
Osceola Upper Bar	107	2,645 15	352 36	1,006 12	4,254 53	506 86	4,897 71	6,563 06	5,044 73	219 88	25,490 40
Osceola Lower Bar	667.4	16,498 80	2,196 74	6,275 56	26,537 15	3,161 47	30,548 90	40,936 31	31,465 91	1,371 50	158,992 34
Bullerton Main Dike	372	9,196 21	1,225 00	3,497 92	14,791 46	1,762 16	17,067 56	22,817 37	17,538 68	764 46	88,620 82
Bullerton Cross Dike No. 1	394	9,740 07	1,297 45	3,704 78	15,666 23	1,866 38	18,034 56	24,166 78	18,575 92	809 67	93,861 84
Bullerton Cross Dike No. 2	290	7,169 09	955 00	2,726 87	11,531 00	1,373 73	13,274 17	17,787 73	13,672 63	596 00	69,086 22
Bullerton Tow-head	1,060	26,204 26	3,490 68	9,963 18	42,137 72	5,021 22	48,509 38	65,007 22	49,965 82	2,168 30	252,467 78
Plum Point Dikes	1,558	38,505 34	5,130 60	14,649 87	61,939 20	7,380 25	71,304 33	95,553 05	73,445 03	3,200 69	371,108 36
Craighead Point	262.5	6,489 26	864 40	2,468 28	10,437 52	1,243 46	12,015 41	16,100 96	12,376 08	601 08	62,596 45
Totals	9,275.9	229,288 53	30,543 87	87,213 86	368,786 99	43,938 73	424,544 84	568,901 77	437,286 81	19,061 28	2,209,566 68

NOTE.—The above table of classified expenditures was prepared under the direction of my predecessor, Captain Knight, and represents the state of affairs at the close of his administration of the work. Late experience has suggested a revision of the pro rata of distribution of indirect expenses, as a result of which some works, on which nothing has been spent in the interim, appear in this table with a slightly less cost than was assigned them in last report.

Expenditures from April 1 to June 30, are: For care of property, $8,830.25, including liabilities of $1,760; for surveys, $2,331.18, including liabilities of $225.

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Approximate value of plant belonging to the United States, and used upon the improvement of the Mississippi River, First District.

Class of property.	Number.	Approximate value June 30, 1885.
Steamer P. Kirns	1	$7,769
Steamer Itasca	1	8,617
Steamer Abbot (new)	1	4,970
Launch Titania	1	1,099
Pile-drivers	37	123,873
Quarter-boats	15	25,704
Mattress-boats	10	27,898
Graders	2	38,814
Derrick-boats	2	5,559
Barges	51	46,821
Machine-shop boat	1	5,303
Whitehall boats	8	280
Skiffs	63	765
Tools and appliances	.....	10,000
Office furniture	.....	100
Surveying instruments	.....	200
Total value	.....	307,772

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REPORT OF ASSISTANT ENGINEER A. J. NOLTY UPON OPERATIONS IN THE FIRST DISTRICT.

UNITED STATES ENGINEER OFFICE,
Sans Souci, Ark., June 9, 1885.

SIR: I have the honor to herewith submit my report of operations at Bullerton Towhead, in Bullerton Chute, and at various other places on Plum Point Reach, for the period beginning October 1, 1884, and ending June 30, 1885.

At the beginning of this period there were six construction parties in the field, viz: Mattress and revetment party at Fletcher's Field Bend; mattress and dike party at Gold Dust; mattress and revetment party at Osceola Bar; mattress and dike party at Plum Point, mattress and dike party at Bullerton, and a mattress and revetment party at Craighead Point Bend.

Work on Craighead Bend bank was started during the first week in September, by beginning the construction of a foot mattress 175 feet wide, and by clearing the bank of timber and drift preparatory to grading and revetting it. From the nature of the soil composing the bank of this bend (silt and sand), the depth of water, averaging 43 feet below low water of 1879, the velocity of the current from 6 feet to 7 feet per second and the rapid caving of the bank, it was at once evident that it would be no easy undertaking to successfully revet this bank. These apprehensions were fully realized as the work progressed. At the beginning of the period 581 feet of mattress 175 feet wide was lying afloat at this place when the accumulation of drift, brought down by a previous rise in the river, broke it loose, parting twelve 2-inch lines. The mattress lodged below the point and was a total loss. After the rise had subsided and the river became clear of drift a new mattress was begun, and 660 feet constructed when a coal barge, laden with staves, struck the head of it. Though the mattress was not injured by this collision, it was accepted as a warning to get it down, and accordingly the piece was sunk, the operation of sinking being successfully accomplished. While this mattress was being constructed the bank in front of it had in the mean time caved so far from its inner edge as to necessitate the construction of a supplementary mattress 50 feet wide to connect the main mattress with the proposed revetment. While this construction was going on the bank was being graded and revetment laid thereon. For grading a hydraulic grader was at first used, but owing to the nature of the soil it was found entirely unsatisfactory. Wooden sluice boxes were then constructed, a cut representing the slope of bank was made into the soil the sluice running from top to foot of bank placed in this cut and the dirt shoveled into it by the men washed was down by means of a pile-driver pump. This plan worked, very well and gave good results both as regards nature of work and cost. Work was continued thus with varying success until about 900 feet of bank had been protected, when the ice coming down put a stop to all further operations there, and by the time the river had become clear of ice, orders had been received to stop all work on the

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reach. The work as far as could be seen had been done in good style and in a conscientious manner by Assistant Engineer Yeager. Yet by the end of February not a vestige of the high-water bank protection was visible and the bank is now caving and sloughing off as bad as previous to beginning of work. Examination of this bank where caving is going on will show that it is mainly caused by that old enemy to revetment work, namely, seepage. No data is at hand from which to compile the amount of material expended on, or the cost of this work.

At Bullerton Tow-head repairs to revetment of outside bank damaged by seepage were being made at the beginning of the period. Here two different plans suggested by experiments carried on during the summer were practically applied. One method was as follows: A trench, 90 feet long, 4 feet wide at bottom, and 16 feet deep was dug from the foot of the bank back. This trench was filled to a depth of 6 feet with stone, and the whole again covered up. The damaged bank was then graded to an easy slope and revetment laid thereon. The piece of bank chosen for the application of this method was at that time sloughing off badly and the semi-liquid material running into the water. So soft was this material a few feet below the top that a stone or piece of drift-wood thrown down would sink out of sight. As soon as the drain was put in a marked change became at once visible. Water ran out of the drain in a small but continuous stream, and the bank on both sides began to dry up rapidly; the drainage influence extended for about 35 feet from the mouth on either side. No damage has occurred here since. The other method which was tried at two different places is as follows: Two rows of piles, 12 feet apart and parallel to the line of bank, were driven, the piles of each row 4 feet apart. The first, or inner row, was driven about equi-distant between the water-line on the bank and the foot of under-water slope. The space included between the two rows of piling and between the foot of graded bank and first row was filled up to water-surface with brush mattresses 3 feet thick and of requisite width, each mattress being sunk independently of the overlying one. The whole structure was well braced, tied, and anchored, and the above-water portion of bank revetted in the usual manner. Unfortunately, owing to insufficiency of stone and brush, only one of these retaining dikes could be finished, the other and much longer one being only partially and its own piece of above-water bank being entirely unprotected. The finished piece looks perfect to date, and the other, though the bank is entirely bare, has undergone no change whatever. With the exception of the unfinished piece of work first mentioned, which is 300 feet long, the outside bank of Bullerton Tow-head is completely protected and the work in good shape.

In Bullerton Chute Cross-dikes No. 1 and 2 were completed by the end of 1884, except that nearly 900 feet of tipped mat remained afloat, owing to lack of stone for sinking. Preparations had been made to take stone off Bullerton Tow-head and other heavily loaded revetments, but before any was received the river had risen high enough to entirely submerge the dike. At a subsequent subsidence of the water a barge-load of brick was distributed over this mat, without, however, accomplishing much good. The brick, in the first place, were badly baked, being hardly more than sun dried, and soon crumbled under water.

Their specific gravity being very low it required a large number of them to sink a given piece of mat, and as the brick were badly broken up and the mat not woven close enough for such ballast, the bulk of the brick passed through the interstices of the mattress. Even under the most favorable conditions of brick and mattress it is safe to assume that $1 worth of stone will accomplish as much as $6 of brick. In closing the gaps in Nos. 1 and 2—necessarily left open until the works above these dikes were finished, as all towing had to be done through them—much trouble was encountered from difficulty in handling and holding the drivers. These gaps were left in the line of deep water; and as the dikes advanced from either side the already strong current increased considerably; several times in lowering piles the drivers were broken loose either by the lines parting or the piles or kevels to which they were fastened breaking off. The greatest retardation the work suffered from was due to failure to receive material as required. Notably was this the case with piling, as not only was the supply insufficient but the kind furnished was very poor. In closing gap number 1 while working in 40 feet of water, only poor cottonwood piles of from 50 feet to 58 feet in length were available. These the assistant in charge was compelled to use as the flood season was approaching and his orders were to close the gaps before high water drove him out. To compensate in a measure for the lack of strength in the individual piles an extra row of piling was added at this place. While closing this gap it was noticed that after the piles had penetrated the foot mattress they would drop down about 6 feet before meeting with any resistance. This phenomenon was noticed for a distance of 40 feet in the first, second, and third rows, but only slightly in the latter, while in the fourth and fifth it was not felt at all. Careful soundings revealed the existence of a deep narrow trough or gully at the bottom, to which the stiff mattress could not accommodate itself, but simply bridged it over. As the down-stream half of this mattress width rested well

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on the bottom it was presumed that this hole would soon fill up. This seems to have taken place not however until the first and second rows had settled down about five feet, still, however, retaining their vertical position. The explanation offered for this action is that as the piles were too short to give more than about 14 feet penetration through mattress the actual penetration in the river bottom was only about 6 feet, this into sand which probably scoured out down to the clay stratum, the mattress acting as a guide and the rear portion of the dike as stays to keep the sinking portion vertical. No further change was noticed, and as a heavy fill has now taken place all along this dike no damage is expected. When the ice began running in the early part of January, 1885, the entire chute above number 1 was blocked solidly with ice, bringing a great pressure to bear against this dike. Upon the river falling sufficiently to expose this work it was noticed that where the short and weak piles had been used the dikes had been forced out of perpendicular for about 50 feet. The water rose again and soon after subsidence and exposure of the dike showed that part broken down. No further damage has taken place here and the gap is too small to retard, fill, or otherwise injure the work. Dike No. 2 is in fine condition with a vast field of drift in its front. It is recommended that when the river falls sufficiently to admit of doing so the tipped mattress at this dike, not yet sunk, be so disposed of as it will then, by checking what little current comes through the chute, induce a more rapid fill. About 200 feet of this mat next the Arkansas bank should, however, for sanitary reasons be left afloat while the fleet is laid up behind there.

While the work in Bullerton Chute was in progress, an examination of Osceola Dike No. 4, which is next above Bullerton No. 1, revealed a weak place in the Arkansas end, which demanded immediate attention. Two pile-drivers were therefore detached from the Bullerton work and sent up to the damaged dike to reinforce it, which was accomplished by driving 200 feet of partly two and partly three row dike behind it. This has enabled the dike to resist the pressure against it, caused by the immense accumulation of drift in its front, and this work has since sustained no damage.

When Osceola No. 4 was under construction, and before more than the first row of piles had been carried over the then submerged sand-bar, the water fell and the drivers had to be withdrawn from work at that place and pushed out into deeper water, there to continue work. It was not until January that the stage of river was again high enough to admit working on the uncompleted portion, and work was continued then until the water rose so high as to seriously endanger the drivers by the probable loosening of the dritts in front, when work was finally abandoned, leaving about 100 feet of three-row uncompleted, but still strong enough to remain until next season. The work at Bullerton Tow-head, in Bullerton Chute, repairs to Osceola Dike No. 4, have been in charge of Assistant Engineer Nolty.

The work at Plum Point consisted in construction of cross-dikes Nos. 4, 5, and 6, extensions of main dike, and construction of foot and tipped mattresses. At the close of the season all the cross-dikes had been extended as far out as the plans of the work called for, and the main dike or training-wall carried down to cross-dike No. 3. In the prosecution of these works much difficulty was caused by the depth of water and velocity of current, especially in extending cross-dikes Nos. 5 and 6 to the required distance out. This work has been in charge of Assistant Engineer Hatfield. At Lower Osceola Bar the work consisted in revetment of outer bank and repairs to old revetment around its head. The grading of the bank here was done with one of the hydraulic graders. Foot mattress constructed here was 150 feet wide. No trouble was encountered here during construction except when drift was running; as at all other works much delay was caused by insufficient supply of material. When the ice began running a large amount of revetment was without any ballast, and as word was received from Captain Knight not to expect any more stone, arrangements were made as soon as the river was somewhat clear of ice to take 25 per cent. of the stone from the finished work and distribute it over the unballasted part. This work has been in charge of Assistant Engineer Seddon.

At the Gold Dust system of dikes work on main and cross-dikes, consisting of new and repairs to the old work, was continued during the period up to the final cessation of work. This system of dikes has always been more difficult to maintain than any other on this reach. Various causes have operated in opposition to this work. Unlike the Plum Point system, this is not protected by a projecting point in the bank which has a tendency to deflect the main current away from the work, but has a straight reach above it, and before the contraction works were put in nearly 50 per cent. of the volume of the river sought a passage through the chutes now closed up. Much work was done here in the early days of the improvement works, and was not built as strong as after experience taught us it must be. Hence there occurred frequent breaks in this old work, which were always closed with much more stable construction, until now very little of this former work is left. The work at Gold Dust has been in charge of Assistant Engineer Geuder, ably assisted by Superintendent Riley.

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At Fletcher's Bend work on bank protection was continued by three different parties at as many different sites. Work was pushed to the utmost here, the aim being to, if possible, finish the revetment of this rapidly caving concave bend before the bevent of the flood season. Had the river remained free from ice, the worst part of the bank at least would have been entirely protected; but the heavy flow of ice necessitated stoppage for several weeks, and by the time ice stopped running, orders were received for a discontinuance of all work, owing to failure of Congress to make an appropriation. All that could be done after these orders were received was to borrow stone from finished works and put enough on the new, yet unballasted work here, to hold it down. The work here is now in two sections, separated by 5,000 feet of entirely unprotected and now caving bank. Snag-boats Meigs and McComb were used here to remove snags and submerged timber in the line of foot mattress. The latter boat was employed only for a short time on such snags as were too heavy for the former to remove. A new method of loading revetment was tried here and found to work well and economically. A pile-driver was laid on the outside of the stone barge and a three-fourths inch wire rope run from the leads at a convenient distance above deck to trees or stumps on the bank, and then fastened. Upon this rope a traveler, having pendent to it a stone-boat capable of containing one cubic yard of stone, was made to run and by means of a hauling line operated by a steam winch the stone was hauled to place and dumped, the empty boat descending by gravity. A few men could distribute the stone evenly as fast as it was dumped. The work at this station has been under charge of Assistant Engineer Gould. The removal of the fleet to the winter harbor in Bullerton Chute was begun the latter part of December, 1884, and continued as fast as plant was put out of commission, until ice in the river prevented all towing. As soon as the ice flow ceased, towing was resumed and continued uninterruptedly until March 15, by which time all plant had been removed.

The force which had already been greatly reduced in number was still further reduced as soon as the plant was all collected. All the assistants except one were discharged, and the permanent fleet party, numbering thirty-five all told, organized. For reasons of economy it was decided by the officer in charge to send up the fleet of the second district to be consolidated with that of the first. The first installment of this plant was received from United States steamer Minnetonka on the 25th of April, and by the 29th all of that plant was up here.

In the mean time it became apparent that where the first district fleet was laid up, *i. e.* along the inside of the Bullerton Tow-head, just below Bullerton cross-dike No. 2, steady fill was going on, and that there would not be sufficient water during the low-water season to float all the plant. It was therefore decided to move everything over to the Arkansas bank, where there was, and still is, deep water. This moving over of the first district as well as moving up of the second district fleet (this latter plant had been tied up along Arkansas bank, but low enough down so as not to interfere with the final arrangement of the whole fleet) was done with the launch H. L. Abbott and tug Itasca, and accomplished in about eight days. The fleet, as finally arranged, extends 4,072 feet along the Arkansas bank of Bullerton Chute, the head of the fleet being far enough below Dike No. 2 to allow the regular mail packet to approach the Sans Souci landing. The fleet, numbering 181 pieces, is divided into three sections, each being five pieces abreast, and connected to the succeeding one by a floating bridge 200 feet in length, this bridge being the continuation of the center line of barges which are all flush-decked ones, and form a convenient footway from end to end of the fleet. The first section is composed of such barges as have no cabins thereon, the second of pile-drivers exclusively, and the third of quarter-boats, steamers, graders, and other plant having cabins upon them. The principal danger to be apprehended is from fire, and the utmost care and vigilance are exercised to prevent an outbreak. The means for combating fire, should any occur, are, it is believed, complete, and consist in a judicious distribution of hand fire-grenades all over the fleet, filled water-barrels and fire-buckets on the decks and roofs of all cabin boats, an organized fire department with an experienced chief, and an excellent fire-boat capable of throwing two 1½-inch streams, upon which steam is kept up night and day. To prevent loss of portable property, it has been collected from the different pieces and stored in various quarter-boats and put under lock and key; special watchmen have been assigned to these boats, whose principal duty is to care for and protect this property. The harbor now occupied by the fleet is an excellent one, having a least depth of 5 feet below low water of 1879. This lowest water being at the head is well protected by the dike against drift and ice, is secure against violent storms coming from any direction except southeast, being land locked on three sides, and has fixed banks the entire length of the fleet. No rapid filling up is indicated here, the water parting with most of its sediment above Dike No. 2, and the lead bringing up only soft mud when soundings are taken along the fleet. A large amount of property remains stored on the bank at Elmot, some in the open air, and the more valuable and perishable kind under shelter. A trusty watchman is in charge of it. Condemned quarter-boat

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No. 3, blocked up on the bank at Elmot, and used as a store-house, was, with most of its contents, destroyed by fire during the night of April 1. Loss estimated at $5,000

The following table shows amount of work done at the various stations on this reach for the period:

At Gold Dust:		
Foot mattress made	squares	3,191
Foot mattress sunk	do	2,928
Tipped mattress made	do	718
Tipped mattress sunk	do	718
Brush cut	cords	302
Dike completed	linear feet	1,645
At Fletcher's Bend:		
Foot mattress made	squares	1,845
Foot mattress sunk	do	3,279
Bank graded	linear feet	500
Revetment made	squares	2,967
Revetment loaded	do	3,400
Snags removed	linear feet	3,000
At Osceola Bar:		
Foot mattress made	squares	3,418
Foot mattress sunk	do	4,370
Revetment made	do	3,909
Revetment loaded	do	4,200
Bank graded	linear feet	2,586
Ditching	do	200
At Plum Point:		
Foot mattress made	squares	650
Foot mattress sunk	do	650
Tipped mattress made	do	1,974
Tipped mattress sunk	do	1,974
Revetment made	do	150
Revetment loaded	do	150
Dike completed	linear feet	900
At Bullerton Tow-head and in Bullerton and Osceola chutes:		
Foot mattress made	squares	1,223
Foot mattress sunk	do	920
Revetment made	do	384
Revetment loaded	do	384
Tipped mattress made	do	150
Tipped mattress loaded	do	420
Bank graded	cubic yards	9,500
Brush filling	do	3,036
Drains constructed	linear feet	100
Dike completed	do	3,012
Brush cut	cords	134
At Craighead Point:		
Foot mattress made	squares	2,093
Foot mattress sunk	do	1,544
Bank graded	cubic yards	33,618
Revetment made	squares	338
Revetment loaded	do	338
Drains built	linear feet	282

In addition to the tabulated work given above a great deal of work was done by the different parties which cannot be properly classified.

PRESENT CONDITION OF THE WORKS.

The condition of the works on the reach at date is about as follows: In Ashport Bend the bank has been protected from the mouth of Forked Deer River to Ashport Landing, a distance of about 3,000 feet. No work has been done here since 1882. Bank from foot of this revetment down to Gold Dust Landing caving badly. The Gold Dust contraction works were completed as projected, and both Chute No. 30 and Elmot Chute would be practically closed up, were it not for the breaks, which occurred during construction and after completion of the system, both in main and cross dikes.

These breaks, of which there are two in main dike, aggregating in width about 800 feet, and in the cross-dikes aggregating 3,500 feet in width, still allow a large volume of water to pass through these chutes. The suggestion is here respectfully offered that

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only the breaks in the main dike be closed by building around the deep water now crossed by a line joining the ends of these gaps and extending back 100 feet inside this line; that the breaks in the cross-dikes be ignored, and in lieu thereof a strong dike be thrown across from Elmot Bar to Island No. 30 on Range 36, and one from the latter island to the Tennessee bank, at about Range 38. The aggregate length of these two dikes would not exceed 1,800 feet. Experience in Osceola and Bullerton chutes has shown that such cross-dikes are more easy to maintain, and will effectually turn the water. Such dikes would also check the caving now going on along the bank of Elmot Bar and Island No. 30. Of course no dike-work should be put in here or anywhere else until the site of such work is first well mattressed.

In Fletcher's Bend the bank protection extends now from near the mouth of Mill Bayou down 2,875 feet. From the foot of this work about 5,000 feet down, the bank is entirely unprotected and caving badly; another section of revetment begins here, running down 1,480 feet and at the foot of this section we strike again the caving bank.

Lower down at Elmot is another section of revetment 750 feet long, the construction of which was necessitated by a suddenly developed tendency of the bank to cave. The bank between the foot of the first and the head of the second section of revetment, and from the foot of this down some distance, is heavily timbered up to the edge of bank, and no doubt when work is resumed the first steps here will be to remove the snags and submerged timber. This timber falling into the river may have a tendency to check caving, and thus lessen the danger which now threatens this second section. At present the chances are decidedly against saving any part of the threatened work. All the works at this section are in first-class condition, except at the extremities of section No. 2, which have to some extent followed the caving bank. Osceola Chute is completely closed and rapidly filling up; all the work here is in good condition. The three principal cross-dikes have vast masses of drift in front of them; that in front of Nos. 1 and 3 being well covered with soil and vegetation.

At Upper Osceola Bar no high-water bank protection is visible; what little of this work that was put there during the early spring of 1883, when the river was quite high, having all slid down. The entire bar has a foot mattress in front of it, and not much caving has occurred here; still this work should be finished as the channel now runs along there.

At Lower Osceola Bar the bank is protected on the outside for 4,339 feet from the head down and around the head down the inside bank to Osceola cross-dike No. 3, a distance of 1,000 feet.

This work stands well, the only damage it sustained having been caused by seepage from some ponds in the rear. These ponds were drained, and no further damage has been sustained. The damage is very slight, consisting of a sliding down of the revetment for 100 feet, the greatest width of bank exposed being 15 feet. Below the revetment the unprotected bank is caving to some extent. At Plum Point when the work ceased the condition of it was as follows: All the cross-dikes, six in number, extended out as far as the plan of the work required. The main or training dike had been carried down to cross-dike No. 3. One break 250 feet wide had been made in cross-dike No. 5, and one 200 feet in No. 6. Since then No. 5 has been shortened about 500 feet by additional loss, and another break in No. 6, nearly 300 feet long, is visible. All the other work is perfect, and heavy fills are apparent. Yankee Bar is still caving in at the head and a large volume of water goes through the breaks and down between Yankee Bar and the Tennessee bank.

At Bullerton Tow-head the entire outside bank, 9,625 feet in length, with the exception of 300 feet, is protected. The 300 feet lacks the high-water protection.

The protection works run around the head and down the inside bank for 500 feet. The bank appears perfect as far as finished and no damage is visible even at the unprotected part of the bank.

In Bullerton Chute a small break, 75 feet long, has been noticed in cross-dike No. 1, due to the poor piles used here. This gap does not appear to be of any consequence and has not increased in width since first noticed last winter. Cross-dike No. 2 is in perfect condition with an immense accumulation of drift in its front. Heavy fills are noted between Nos. 1 and 2, and above the former. At Craighead Point all the revetment put in has disappeared. The foot mattress, however, is evidently doing some good in preventing the caving, which below it is very serious. At Gold Dust there are now stored about 1,600 cubic yards of stone received after the close of operations. Since the close of operations a regular system of periodical inspection of work, and of soundings and velocity measurements over the more changeable portions of the reach, instituted by you, has been conducted. The latter data are yet too meager and obtained at too high a stage of river to justify me in venturing any prediction as to the ultimate results of the completed work, or the final location of the low-water channel. Valuable information has been obtained and the notes taken are carefully collected and preserved for further reference and comparisons. Your attention is again respect-

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fully called to the destruction of large quantities of willows on Osceola Bar by private parties, who claim that they have entered the land there and are cultivating it. A rumor has reached me that parties are contemplating taking possession of other tow-heads, no doubt with a view of charging high prices for needed material when such is wanted; some of the branch ditches cut at Osceola Bar to lead the water into the main ditch have been plowed over and practically closed. Such actions strongly point to the necessity of legislative enactment, whereby the control of these lands is given entirely to the commission and its officers.

Respectfully submitted.

AUG. J. NOLTY,
Assistant Engineer.

Capt. SMITH S. LEACH,
Corps of Engineers, U. S. A.

APPENDIX H.

REPORT OF CAPTAIN SMITH S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE SECOND DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 18, 1885.

GENERAL: Pursuant to the instructions contained in your letter of the 1st instant, I have the honor to submit the following report of operations in the second district, Mississippi River, from October 1, 1884, the date to which progress was last reported to Congress, to the end of the present month and fiscal year.

I relieved Capt. Clinton B. Sears, Corps of Engineers, of the charge of this district on March 10, 1885. At that date all operations were suspended and the force reduced to that absolutely required for routine office work and care of property.

MEMPHIS REACH AND HARBOR.

On this work the assistant in charge, Mr. W. M. Rees, had been retained, and I am able to submit herewith his report, giving full details of the work with which he has been associated from the beginning, and of which he has a knowledge which can only be gained by such association. (See Appendix H 1.)

The work on the Memphis reach has been entirely for bank protection. That on the Memphis Levee, from the magnitude of the local interests involved, was brought up in grade very much above anything yet attempted when navigation alone was at stake. The gravity of the situation also forbade the beginning or prosecution of the work under unfavorable conditions, and the more adequate supply of plant prevented serious distress from lack of material. Under these circumstances a work was constructed very much superior in strength and completeness to any heretofore done on the river, and at a cost not exceeding that of some inferior work, attempted elsewhere under adverse conditions, and harassed by lack of material during construction. If protection of the caving banks of the Mississippi River will justify an expenditure of $25 per running foot, a revetment like the one in question can be put down for that money and will do the work. This with the proviso that no piece of work be undertaken until money and material to complete it are in sight.

The work in Hopefield Bend has stood well. The only loss to be reported is that of some 2,000 feet of partial upper bank work put in in 1883. Its top edge was against the foot of a bluff bank 10 feet high. It was intended to complete it before the close of operations last season, but the sudden rise prevented. The full work of last season has been damaged in four or five places by the development of faults or slides down the bank.

The continuity of the work appears not to be broken, nor is the bank allowed to cave, but of course the probability of a break is much increased by these slides. They are probably due to the softening of the foundation of the mattress by sipe-water. The semi-fluid mass acts as a lubricant and allows the mat to slide. Drainage and anchoring to the bank will meet this difficulty.

LEVEES.

The only levee work done in this district during the past fiscal year has been the repair of the Long Lake Levee from Old Town, Ark., up.

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From the last appropriation $15,000 were allotted for the repair of this levee, provided "the district officer, upon examination of such levee, shall find its condition to be such as to require such repairs for its safety; and provided also, that said sum shall not be expended until the levee from Helena to the upper end of Long Lake Levee shall be first, and prior to November 1, 1884, repaired and completed to a grade 2 feet above the flood of 1882."

These conditions having been complied with, it was decided by Captain Sears, the district officer, to begin the repair work at the lower end, where there were a number of large gaps and a scanty population, and work up-stream as far as the allotment would permit. He thought the large population behind the upper end of the levee would for its own safety strengthen this portion. Proposals for this work, amounting to some 60,000 cubic yards, were advertised October 25, 1884, bids were opened November 5, 1884, and the contract was awarded to the lowest bidders, Messrs. Winters & Cooney, at 23 cents per cubic yard.

Work was begun immediately and finished in March, 1885.

The whole allotment was expended in engineer's expenses, inspection, and contractors' estimates.

The following financial statement and general balance-sheet show the condition of allotments and expenditures for this district:

APPROPRIATION FOR IMPROVING MISSISSIPPI RIVER, ACT OF JULY 5, 1884, SECOND DISTRICT.

Financial statement.

Balance on hand October 1, 1884, as per last report:		
Memphis Reach and Harbor		$183,327 03
Long Lake Levee		15,000 00
		198,327 03
Amounts received since:		
On account of sale of fuel	$33 75	
On account of overpayment	281 81	
		315 56
		198,642 59
Expended from October 1, 1884, to June 15, 1885:		
Memphis Reach and Harbor	180,333 03	
Long Lake Levee	15,000 00	
Total expended	195,333 03	
Estimated liabilities to June 30, 1885	1,750 00	
		197,083 03
Balance June 30, 1885 (Memphis Reach and Harbor)		1,559 56

GENERAL BALANCE-SHEET.

Improving Mississippi River, Second District, Memphis Reach and Harbor.

Dr.					Cr.
1882.			1884.		
Aug. 2	To allotment	$325,000 00	Feb. 29	By expenditures of secretary of Construction Committee from Memphis, allotments to date	$167,009 22
1884.					
Jan. 18	do	90,000 00			
Feb. 29	To deposit, sale of fuel	9 22			
July 5	To allotment	200,000 00	1885.		
Oct. 31	To deposit, sale of fuel	11 25	April 1	By expenditures of secretary of Construction Committee, from allotment for general service to date	54,870 89
Dec. 31	do	11 25			
1885.					
Jan. 26	do	11 25			
Feb. 6	To overpayment refunded	281 81			
April 1	To general service charges to date	54,870 89	June 15	By expenditures of district officers to date	445,006 00
			June 30	Estimated liabilities to date	1,750 00
			June 30	Balance	1,559 56
		670,195 67			670,195 67

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Improving Mississippi River, Second District, Long Lake Levee.

Dr.					Cr.
1885. July 5	To allotment	$15,000 00	1885. June 30	By amount expended by district officers	$15,000 00

A table of value of plant is appended.

Expenditures classified as far as the present condition of the records admits will be found in Mr. Rees's report.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers.

General Q. A. GILLMORE,
President Mississippi River Commission.

Approximate value of plant belonging to the United States, and used upon the improvement of the Mississippi River, Second District.

Class of property.	Number.	Approximate value June 30, 1885.
Steamer H. M. Graham	1	$4,650 60
Launch Daphne	1	1,380 00
Flat-boats	3	931 50
Mattress-boats	2	8,280 00
Machine-shop boat	1	5,865 87
Screen boats	4	4,140 00
Quarter-boats	4	6,266 53
Survey boat	1	779 41
Barges	24	30,070 20
Skiffs	15	255 30
Pile-drivers	9	28,613 67
Coal-sheils	2	414 00
Tools and appliances	.....	5,000 00
Office furniture	.....	150 00
Surveying instruments	.....	150 00
Total value	.....	96,947 08

H 1.

REPORT OF ASSISTANT ENGINEER W. M. REES UPON OPERATIONS IN THE SECOND DISTRICT.

MEMPHIS, TENN., *June* 17, 1885.

CAPTAIN: I have the honor to submit my report upon the work of improving Memphis Reach and Harbor from October 1, 1884, to June 30, 1885.

MEMPHIS HARBOR.

This work was in progress on October 1, 1884. At that time several unsuccessful attempts had been made to sink mattresses 250 feet and 300 feet wide. These widths were deemed necessary in order to reach the greatest channel depth, which was from 80 to 100 feet.

After the second mattress broke, whilst sinking, the plan was postponed until suitable material for stronger construction could be obtained, and also until a more favorable condition of the river presented, as it was then rising with drift running. In the mean time work on constructing mattresses 150 feet wide was begun and these were placed along the city front from Wolf River to below the foot of Jefferson street, and also extended above Wolf River for a distance of 1,230 feet and into Wolf River for a distance of about 150 feet, forming a sill across its mouth. All these were sunk during low water. They were well anchored to fastenings on the bank with wire cables

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every 50 feet. The bank was then graded to an easy slope, and a revetment of double thickness of brush placed thereon; this was covered with stone in juxtaposition. Soft places on the bank and pockets near the water line were covered or filled with cypress bark. Care was taken to connect well the upper and lower revetments, and where they could not be wired together floating mattresses, continuous with the upper revetment, were built to overlap the lower work by at least 30 feet. This overlapping occurs for about three-fourths of the entire length of revetment, making at or near low-water line a double thickness. To prevent steamboats from displacing the brush of the upper revetment wire cables were placed alongside the transverse poles and wired to the grillage poles below. Preparation being completed, and the water being sufficiently low, work on mattresses 250 feet wide was resumed on November 4, the project being to place these on top of the 150-feet mattresses from Wolf River to Jefferson street. Work began as near below Wolf River as it was considered safe to place mooring barges, the lines from which could not be led across the river without interfering with the transfer steamboat.

Especially constructed mooring barges held the head of the mattress. The latter w s strengthened by more and better constructed iron chains than used on previous mattresses, and also by weaving through and near its outer edge two 2-inch manila lines and one 1¼-inch line; these were sunk with the mattress. In sinking one of these 600-feet long mattresses I used sixteen ropes at the head and three ropes leading diagonally across and fastened at different points to the mattress. Nearly all ropes were of 2-inch diameter. The outer two at the head were of 2½-inch diameter. In all, three mattresses were sunk, extending from 400 feet below Wolf River to the middle of the Memphis Elevator, a total length of 1,567 feet. More would have been placed had not the rising water rendered it unsafe to proceed.

To protect the work from the effect of sipe water a number of drains were built; one was a plank box 12 inches by 18 inches inside, draining the waters that collect under the Memphis Compress Company's shed into Wolf River; its length is about 1,000 feet. Others were placed along the bank, made either of plank or of stone, placed upon a foundation of cypress bark.

Incidental to preparing the bank for revetment, foundation walls and piling were removed and the wreck of a large model barge blown up with dynamite.

A cave on the paved levee at foot of Jefferson street took place during the high water of 1884; this was repaired by the city authorities during the summer, but it again caved out during November. The paving ended against a row of piling along which scouring was taking place, due to the eddy from the sunken barge above. This was repaired the second time by sinking three or four mattresses 24 feet wide on top of each other and against the piling, using a liberal quantity of stone, thus forming a revetment wall to support the levee. The slope of bank outside was nearly flat.

The total length of bank revetment is 4,680 feet. The entire work has stood the test of this year's high water very successfully, showing no signs of weakness although the current in front of it is as strong as before, when caving was taking place.

HOPEFIELD BEND.

The project here was to replace the revetment washed out during the high water of 1884 and to repair breaks and weak places in the work above.

The new revetment work extended 3,300 feet. It was constructed by first driving a row of piling a few feet out from low water, against this a mattress 150 feet wide was built and well secured to the piles before being sunk. The upper revetment extends from the top of the bank to 24 feet beyond the piling around which it is built. When sunk, this laps the lower revetment by 24 feet with a pile passing through each every 8 or 9 feet. The construction was the same as in Memphis Harbor. The work was completed during November, when the entire force of over 200 men began repairing the upper bank caves of last year, and placing protection work upon places where it had then been omitted or was of insufficient strength. This was continued until the closing of the work by high water and running ice, and was then in an unfinished condition.

In addition a mattress 686 feet by 150 feet was placed across Mound City chute to replace work washed out by the cave of December, 1883.

A large amount of work was done in repairing former work, as nearly all upper revetment had been made of insufficient strength and the connection with the lower work was very inferior. The upper bank caved: (1) Through want of proper protection, the work not being covered to the top, but ending against a hard stratum, which, however, slowly washed, allowing the water to get behind the revetment. (2) Through inferior construction of upper revetment, particularly where joined to lower mattress, causing breakage upon slight settling of bank or mattress, and exposing a portion of the bank to the river. (3) Through settling of entire revetment towards the deep water, caused by the revetment not reaching to the deep channel, thus allowing it to be undermined. (4) Sipe water softening the material under the revetment usually near the low-water line. A large portion of the revetted bank is composed mostly of sand.

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Before closing work the bank below was cleared of timber to facilitate the caving of Hopefield Point and thereby relieve the pressure against the Memphis front. The width of clearing was 200 feet back, just below the work, and 600 feet at the end of the timber about 3,000 feet below. During this year's high water all this clearing has caved in, the caving continuing to Hopefield Point, where it is about 525 feet. Here the Memphis and Little Rock Railroad Company were compelled to move their transfer incline not less than five times.

No serious caving has taken place along the revetted bank, and it is thought that the lower revetment is unbroken. The upper revetment shows breaks in a number of places, the most noticeable being about the middle of the work, where no sign of the mattress work was seen at the 12-foot stage, although here it had been carried to the top of the bank. The bank settled in a series of vertical prisms behind the work, gradually lowering out of sight. Whether the lower revetment is still in place I cannot say, although from the small extent of the caving back, the presence of the work immediately above and below, and the strong current in front, I judge it is unbroken, but has settled towards deep water.

Some slight recession has taken place just below the head of the timber, where the upper bank is of hard material, and where no work was placed last season. The lowest stage of water (12 feet) showed that about 300 feet of the lower end had caved off. With a deep eddy immediately below, and also that the upper edge of the new work had settled in four places, the largest being about 15 feet down by 300 feet across. Whether this settling is due to sipe water or to the moving down of the lower revetment it is impossible now to determine.

No caving has taken place above Mound City Chute, where it caved considerably during the high water of 1883 and 1884.

Caving has taken place on the head of Old Hen Island and on the Tennessee shore just above the steamboat channel across Owen's Bar, being nearer the Tennessee shore and fully 3,000 feet lower than last year.

Towards the close of the work the supply of stone ran out, and I had to resort to ballasting with sacks filled with gravel, a good quality of which was obtained near the work; 33,900 sacks were used, the average weight being 185 pounds each.

SURVEYS.

A survey party was employed until February 4, 1885. They made a triangulation survey from Island No. 40 to President Island, establishing range stations, and sounding over them at regular intervals, but as no soundings have been taken since high water no comparison as to changes can be made.

PLANT.

No new boats or barges have been added and none lost from service. All the floating property is in fair serviceable condition. Pumps for hydraulic grading were placed on a pile-driver hull in November, 1884. They discharged about 450 gallons per minute at a pump pressure of 225 pounds per inch, grading during ten days of work an average of nearly 200 cubic yards of earth per hour, at a cost of 2 cents per cubic yard. Two graders were employed.

Statement of work done.

MEMPHIS HARBOR.

Mattress made, 1,770 feet by 150 feet	squares		2,655
Mattress sunk, 2,071 feet by 150 feet	do		3,107
Mattress made, 1,567 feet by 250 feet	do		3,918
Mattress sunk, 1,567 feet by 250 feet	do		3,918
Upper bank revetment, completed	do		5,912
Earth removed, hydraulic grading	cubic yards	17,481	
Earth removed, hand grading	do	5,963	
			23,444
Cypress bark placed on bank	cords		1,850
Box-drains built	feet		1,200
Material used:			
Brush	cords		11,978
Poles	do		440
Stone	cubic yards		13,654
Lumber	feet, B. M.		21,823
Bark	cords		1,850
Wire	pounds		95,142
Wire rope	do		14,733
Iron rods	do		85,867
Spikes	do		22,500

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HOPEFIELD BEND.

Mattress made, 2,815 feet by 150 feet	squares..	4,243
Mattress sunk, 2,978 feet by 150 feet	do....	4,467
Upper bank revetment, completed	do....	6,536
Earth removed, hydraulic grading	cubic yards	63,251
Earth removed, hand grading	do.... 9,861	
		73,112
Banks cleared of timber	acres..	26
Gravel loaded in sacks	cubic yards..	3,135
Material used:		
Brush	cords..	14,674
Poles	do....	282
Stone	cubic yards..	6,487
Wire	pounds..	98,090
Spikes	do....	17,800
Gravel	cubic yards..	3,135

COST OF WORK.

Memphis Harbor:		
Mattressing	$60,867 23	
Grading	3,581 62	
Hauling bark	1,408 50	
Building drains	405 65	
		$66,263 10
Hopefield Bend:		
Mattressing	55,138 82	
Grading	5,599 74	
Clearing bank	366 20	
Loading gravel	1,238 34	
		62,343 10
General work:		
General administration and care of fleet	10,212 47	
Surveys	1,928 63	
Steamers	7,018 56	
Construction of plant	2,359 34	
Repairs to plant	7,389 12	
Transferring rock	3,583 90	
		32,492 02
		161,098 22

Respectfully submitted.

W. M. REES,
Assistant Engineer.

Capt. SMITH S. LEACH,
Corps of Engineers.

APPENDIX I.

REPORT OF CAPTAIN C. B. SEARS, CORPS OF ENGINEERS, UPON OPERATION IN THE THIRD DISTRICT.

I.—LAKE PROVIDENCE REACH.

For an account of the extent of this reach, its physical characteristics, and the general project for its improvement, reference is made to the commissioner's report for 1883. All work done during the nine months past has been in conformity with the general project therein set forth.

The greater portion of the work has been bank revetment, to secure Louisiana Bend, Pilcher's Point, and prevent thereby a radical change in the regimen of the river immediately below, accompanied by a possible destruction of the contraction works there situated and a serious impairment of the good low-water channel which has resulted from these works.

The contraction work has been confined to repairs in former work, the construction of three cross-dikes in chutes, and the building up to a higher level of the wattling on the main dikes.

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The contraction work was brought to a close January 2, and the revetment work January 31, 1885, and the working forces discharged.

A survey party was maintained until March, 1885, engaged in slope and discharged observations and quarterly and special surveys.

Congress having adjourned March 4 without making any appropriation, the survey party was discharged and the force in charge of public property reduced to one assistant engineer at a reduced salary and a small number of boatmen and laborers just sufficient for the care of the fleet. This latter was assembled at Wilson's Point and put in good shape for care and preservation. It consists of two hundred and eleven pieces.

(1) *Duncansby to Stack Island.*

Assistant Engineer Arthur Hider, in immediate local charge, assisted by Assistant Engineer Childs, in charge mattress and revetment work; Assistant Engineers Ruple and Tollinger in charge of dike work; Assistant Engineer Thompson in charge of surveys and observation.

DUNCANSBY SYSTEM.

No further work has been done here. The main channel has continued its encroachment on the dikes at the head of the Duncansby Chute, and has carried away everything above cross dike No. 8 except a few hundred feet of No. 7. This cross-dike (No. 8) and the main dike below are all that remain of the Duncansby system.

The dikes that have been cut away by the main channel encroaching bodily had practically accomplished the object of their construction, viz: The closing of the head of Duncansby Chute and the consequent elimination of the danger of the main channel shifting into this chute. The angle of direction of the axis of this channel is now so obtuse with reference to the axis of the chute as to obviate this danger.

MAYERSVILLE SYSTEM.

Cottonwood dikes.—These dikes were finished at date of last annual report. No repair work has been done and but little needed. At present date the water has not fallen sufficiently to determine by inspection the amount of fill behind these dikes caused by the winter and spring rises. It will not be very great, as the rises have not been high, 35.13 feet on Lake Providence gauge, 3 feet lower than high water, 1884. The water was charged with comparatively little sediment.

Mayersville Chute.—An additional cross-dike (No. 3) has been built in the chute about 500 feet above Range 55. It is 450 feet long. One hundred and twenty linear feet of double dike, to strengthen No. 1, has been built.

The channel has continued its encroachment on the dikes at the head of the chute. The small portion remaining October 1, 1884, has all been carried away, together with some 750 feet off the head of the island. Here, as at Duncansby, the direction of the main channel has become so oblique to the chute as to allay any fears of its going down this chute.

REVETMENT OF MAYERSVILLE ISLAND.

Further repairs to the revetment work at the head of the island, covering some 700 linear feet of bank, were made in October, but, as foreshadowed in my last report, this has all been carried away by the direct impingement of the main channel. The island is made up entirely of fine sand, and the current at the head and along the river front is very strong. The whole head and front have been revetted twice, and a portion of the head three times, that is to say, the original length of the revetment was 8,930 linear feet, but work representing 15,578 linear feet has been done.

There is now standing but 54 per cent. of the original linear length.

BALESHED SYSTEM.

Two cross dikes in the Baleshed Chute, continuation of Nos. 8 and 11, 506 and 667 linear feet, respectively, have been built, and the wattling on the main dike raised several feet. The low water at time of construction, and want of funds after the water rose, prevented the entire completion of these two cross-dikes, and the refilling of the gap in the diagonal dike at the head of Stack Island, made for the passage of plant.

During the last high water in January a gap was made in the main dike between cross-dikes Nos. 8 and 9. This was the oldest part of the dike; the piles were very rotten, and were probably broken off by drift. This gap is now about 1,000 feet wide, and on June 4 had 15 feet of water through it in deepest part; Lake Providence

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gauge, 23.5 feet. This gap should receive early attention, as soon as funds are available, as the direction of the current is acute with reference to the main channel, and the river may take its course down back of Stack Island.

The place in main dike between cross-dikes 5 and 6, that gave so much trouble last fall, and which was repaired the last of the season, has stood well, and is in a fair way to fill up and permanently strengthen itself.

For further details of the work see report of Assistant Engineer Hider herewith.

(2) *Louisiana Bend, Pilcher's Point.*

Assistant Engineer J. E. Turtle in charge, assisted by Assistant Engineers Steubling and Armstrong.

This is entirely revetment work, and consists (1) of a mattress built on the water and sunk so as to bring its inner edge at low-water mark, the width of the mattress extending along down the under-water slope; this is the lower-bank protection; (2) of a mattress, well ballasted with riprap, built in situ on the bank from low to high water mark, after the bank has been graded to a uniform slope of from 1 to 2 to 1 to 4; this is the upper-bank protection, and (3) of a lapping foot-mat attached to the upper mattress and extending out, so as when sunk to lap well over the lower mat, thus covering and strengthening the connection between the two.

At the date of last report the lower bank had been revetted from Range 17 to Range 21¼, a distance of 10,000 feet. The upper bank had been graded and revetted from Range 17 to Range 18.7, a distance of 3,600 feet, and the upper bank graded, but not revetted to a further distance of 1,450 feet. Since then the low-water revetment has been continued to Range 22.4, a further distance of 2,500 feet; the upper bank has been graded and revetted a further distance of 7,850 feet down to Range 21.9, and graded, but not revetted, a further distance of 1,050 feet, or down to Range 22.4; a foot-mat connecting and strengthening the upper and lower bank revetment has been constructed from Range 17 to Range 22.4, a distance of 12,500 feet.

Work stopped on January 31, for want of funds. At this date the bend was well revetted from Range 17 to 22.4. The work had been thoroughly well done and there was every prospect that the bank would hold. The lower mattress extended well out on the lower slope, in a number of places opposite pockets being over 300 feet wide. No accidents occurred to any mattress in sinking, and all went down in good shape. The upper bank was well graded before revetting, and the brush revetment was well and heavily ballasted before the water began to rise.

Soon after work stopped, about February 5, breaks began to take place at irregular intervals, and continued up to April 20. These were in length from 50 to 400 feet, and extended back from 0 to 125 feet. As yet the water has not been low enough to examine the lower part of the revetment. No local causes for these breaks can be determined. In some places the upper bank revetment seems to have slipped down, leaving the bank vertical but without further caving, while in other places the caving has extended back some 125 feet, and the upper mattress has either flattened out on to the bottom, or, revolving on its lower edge where attached to the lower mattress, has tipped forward and dumped its ballast and remains floating on the water.

A survey made in March, 1885, and compared with that of November, 1884, showed that there has been no general deepening of the channel, but the deep water has shifted over towards the concave shore, and the lower mattress has sunk down and flattened out, dragging the upper mattress with it in places. This accounts for there being as yet no falling back of the general line of the bend where it has been revetted. The part below the revetment, *i. e.* down-stream, has caved back from 200 to 600 feet, clear down to the point on Range 26.

During the last high water the current in the bend was exceedingly strong and turbulent, with many boils and eddies. The bank above the head of the revetment, which for years had resisted the action of the current, gave way suddenly during the last high water and caved back so rapidly that a planter had not time to move away a lot of baled cotton placed on the bank for shipment.

Of the original 12,500 feet of revetment, there is now left only 70 per cent., or 8,750 linear feet, showing a loss of 3,750 feet. Had we had the money and means to begin repairs as soon as each break first developed, we doubtless could have reduced the percentage of loss very materially. I apprehend no further caving until next high water, when I should not be surprised to see the rest of the revetment go.

I confess my deep disappointment at the result of this work. It seems to me to demonstrate that the average bank of the Lower Mississippi cannot be held at a reasonable cost by this form of revetment. Had the bank been revetted with double lower mattress as was done along the Memphis City front, I think it would have held, but the cost would have been about double what it was, or about $30 a linear foot.

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FINANCIAL STATEMENT.

Improving Mississippi River, October 1, 1884, to June 30, 1885.

Balance available October 1, 1884		$263,492 67
Refunded on account of an overpayment		10
Transferred from the general service		56,000 00
Received from sale of fuel to officers		31 50
Transferred from Vicksburg, Harbor allotment		2,000 00
Transferred from levees, Tensas front allotment		7,700 00
Transferred from levees, Yazoo front allotment		2,000 00
Transferred from survey, Choctaw Bend allotment		1,320 14
Total		332,544 41
Expended from October 1, 1884, to June 30, 1885:		
Services	$131,209 66	
Material and supplies	86,485 29	
Subsistence	29,546 65	
Plant, tools, and repairs of same	46,434 61	
Charter of steamers and barges	3,130 00	
Fuel	8,881 51	
Miscellaneous	4,786 24	
		310,473 96
Balance June 30, 1885		22,070 45

Of this balance $3,880.67 is pledged to meet unpaid liabilities.

(3) SUMMARY.

The original condition of the channel-way along the Lake Providence Reach was bad, the channel being flat, badly defined, and often in extreme low water, with only 5 feet depth.

The original project for improvement was the narrowing of the water-way to 3,000 feet by closing the chutes and creating artificial banks through deposition and the preservation of the natural curves of the river by revetting the caving banks. No important changes have been made in the general plan.

The total amount expended to October 1, 1884, was $1,863,653.15.

At that date the availability of the channel for the purpose of navigation and commerce had been greatly improved, there being throughout the reach a depth of not less than 15 feet with a fair navigable width and regular course.

During the nine months ending June 30, 1885, there have been expended $310,473.96. The channel has continued to improve.

November 29, 1884, Lake Providence gauge, 6.58 feet.

Stack Island crossing had 19 feet against 17 feet September 19, 1884, gauge 6.6 feet; and Ben Lomond crossing had 16 feet November 29, against 15 feet; September 19.

There are indications that the channel opposite Shipland may divide in low water and go down on both sides of Ajax Bar. If this occurs the crossing here will probably be the shoalest on the reach. It may be necessary, when work is resumed, to close one of these channels.

I am not prepared to ask for any definite sum as being the amount that can profitably be spent during the next fiscal year, as this will depend upon whether we continue the experiments of revetting caving banks.

For the repairs of dikes in the Mayersville and Baleshed systems, the repairs of plant, care of property, &c., and dike work at Ajax Bar, if it prove necessary, $200,000 can be profitably expended.

If revetment work be renewed, $400,000 in addition can be expended during the fiscal year ending June 30, 1886.

The advantages and benefits to be expected from the repair of the dikes will be the maintenance of the present good low-water channel.

An estimate for the entire and permanent completion of the work of improvement on this reach I am unable to give, not knowing the intentions of the commission as to the ultimate extent of the work. As this work is only one link in the chain of general improvement of the river, the amount of commerce and navigation that will be benefited is that incident to the whole river.

The present estimated value of the plant, tools, and outfit on hand belonging to the reach is $340,000.

II.—VICKSBURG HARBOR.

Assistant Engineer H. St. L. Coppée, in charge.

The work here consists of the improvement of the harbor proper (Centennial Lake, in front of the town) and the maintenance of Delta Point, Louisiana, opposite Vicks-

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burg. The former is entirely local in character, and would add nothing to the general improvement of the river. No funds were allotted from the last two appropriations, and no work has been done.

DELTA POINT, LOUISIANA.

The holding of this point is deemed essential to prevent further recession of the river from Vicksburg and to maintain the regimen of the river immediately below. This has been held by a mattress and riprap revetment for nearly three years, but at considerable expense for repairs and enlargement.

The work on the down-stream prolongation of the revetment was finished October 10, 1884. In March two slides took place in the upper bank revetment, just below a large eddy, about the middle of a length of the revetment. They aggregate about 400 feet in length along the water line. The sliding then stopped, and was accompanied by no material caving. Funds having been assigned, I ordered plant and material sent down from Lake Providence Reach, and these breaks were repaired, taking about six weeks and costing some $9,400. No further damage has taken place, and none is apprehended until the next high water.

The Vicksburg and Shreveport Railroad has shown its faith in our ability to hold the point by ordering an incline to be built at Delta Point to be used for the transfer of trains in connection with an incline on the Mississippi side. The one on the Louisiana side will cross over our revetment, and its stability will depend upon that of the revetment.

The total expenditure on Vicksburg Harbor under the Commission to June 30, 1885, has been $166,792.25, and of this about $110,000 has been expended on Delta Point. Previous to the Commission taking charge $203,229.87 had been expended on Delta Point.

It would be well to have $20,000 available during the next fiscal year for repairs on this work should more weak places develop.

FINANCIAL STATEMENT.

Balance available October 1, 1884	$10,720 69	
Allotted November 1, 1884	4,000 00	
Transferred from general service allotment	10,000 00	
		$24,720 69
Expended from October 1, 1884, to June 30, 1885:		
Services	$8,469 93	
Material and supplies	6,164 69	
Subsistence	1,732 37	
Plant, tools, and returns	575 82	
Charter of steamers	714 00	
Fuel	811 50	
Miscellaneous	569 50	
	19,037 81	
Transferred to Lake Providence allotment	2,000 00	
		21,037 81
Balance June 30, 1885		3,682 88

Of this, $2,958.82 is pledged to meet unpaid liabilities.

LEVEES.

Yazoo front.—The $20,000 allotted for this front in the third district has been expended in repairs to United States levees from Riverton to Huges, and Clay and Bagott's to Easton, Miss.

Proposals were advertised October 8, 1884. Bids were opened October 20; contracts were made with the lowest bidders respectively on the two sections, viz: From Riverton to Huges, some 33,000 cubic yards, to W. C. P. Jones, at 22 cents a cubic yard for earth-work, 1 cent a square yard for tuft-sodding, and 2 cents a square yard for solid sodding; from Clay and Bagott's to Easton some 32,000 cubic yards, to L. C. Dulaney, at 23 cents a cubic yard for earth-work, 1 cent a square yard for tuft-sodding, and 9 cents a square yard, for solid sodding.

These contracts were fulfilled and the work finished on both sections in February, 1885.

Tensas front.—The work of filling gaps in the levee from Delta to Bedford, and Raleigh to Willow Point, La., 94,000 and 125,000 cubic yards, respectively, let to George

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Arnold, and referred to in my last annual report, was begun in October, 1884, pushed forward energetically and satisfactorily finished in February, 1885. Proposals for the repair of the levee from Wilton to Raleigh, and Pecan Grove to Willow Point, La., some 15,000 cubic yards, and on the Buckhorn levee from Omega to Rose Hill, La., some 5,000 cubic yards, were advertised November 25, 1884; bids were opened December 5, 1884, and the contract awarded to Joseph C. Neely, at 26½ cents a cubic yard. The work was all topping work, and was finished in March, 1885.

There not being sufficient funds to make earth-work repairs to the Illawara main front, rough lumber was bought and this front revetted with boards, end on and spiked to sills anchored in the old levee.

The necessary guarantees having been given, proposals for building the levee from Arkansas City to Amos Ridge, Ark., some 325,000 cubic yards, were advertised November 2, 1884, bids were opened November 8, 1884, and the contract awarded to the Tennessee Industrial Company, John D. Adams, president, at 24 cents a cubic yard, including clearing and sodding. The contractors guaranteed to build the whole line under my direction and to my satisfaction, and to receive for their work not to exceed $25,000, the amount allotted.

Work was begun in November and satisfactorily finished in April.

This, for the first time for years entirely closes this line and the head of Tensas interior basin. There are now but two gaps in the United States line below Arkansas River, viz, at Duffin's and Panther Forest.

FINANCIAL STATEMENT.

Levees—Yazoo Front.

Balance, October 1, 1884		$23,594.25
Expended:		
Services	$2,338 89	
Labor and material	245 66	
Contractors' estimate	18,488 72	
Miscellaneous	346 43	
	21,419 70	
Transferred to Lake Providence allotment	2,000 00	
		23,419 70
Balance available June 30, 1885		174 55

Levees—Tensas Front.

Balance, October 1, 1884		$57,186 47
Expended:		
Services	$3,563 19	
Labor and material	1,471 85	
Subsistence	8 50	
Plant, tools, &c	889 84	
Contractors' estimate	42,831 96	
Miscellaneous	688 87	
	49,454 21	
Transferred to Lake Providence allotment	7,700 00	
		57,154 21
Balance, June 30, 1885		32 26
Levee, Arkansas City to Amos Ridge, allotted		25,000 00
Expended for engineering, inspection, and contractors' estimate		25,000 00

Respectfully submitted.

CLINTON B. SEARS,
Captain, Engineers.

To Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

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I 1.

REPORT OF ASSISTANT ENGINEER ARTHUR HIDER UPON OPERATIONS IN THE THIRD DISTRICT.

WILSON'S POINT, LA., *June* 8, 1885.

SIR: The following report of the operations of the Lake Providence construction party from October 1, 1884, to June 30, 1885, is respectfully submitted:

The construction work done since the last report has been confined to repairs to the revetment at the head of Mayersville Island, which had begun to cave; the construction of additional cross-dikes in Mayersville and Baleshed chutes and wattling the dikes that had heretofore been built on Baleshed Bar and Stack Island.

Extensive repairs became necessary to the revetment along the face of Mayersville Island as the season advanced, the sliding and caving increasing. These repairs were completed December 6, 1884, and the work to all appearances left in good condition to withstand the winter rise.

The cross-dike across Mayersville chute, 500 feet above range 55, was finished except sinking the foot-mat. Cross-dike No. 8 in Baleshed chute was finished complete, but No. 11 and the gap in Stack Island main dike were necessarily left in an unfinished condition by reason of the sudden suspension of work.

EFFECTS OF THE LAST HIGH WATER ON THE CONSTRUCTION-WORK DIKES.

Duncansby dikes.—The river channel has still further encroached on the bar at the upper end of the Duncansby chute, further scouring out the outer ends of the cross-dikes, as had been anticipated in the last report.

However, the river shows no disposition to go down the chute; the caving has entirely ceased, there is little current, and the dikes originally constructed at the head of this chute may be considered to have served the purpose for which they were designed, viz, to prevent the enlargement of the chute and overcome the tendency of the river to take this course.

Gaps about 50 feet wide have been washed out in Cross-dikes No. 7 and No. 8, near the Mississippi shore.

Cottonwood dikes.—This system of dikes has suffered but little damage; a few piles in the outer rows of the main dike have been broken off by drift. The bar behind these dikes has increased both in height and length.

Mayersville dikes.—The main cross-dike has remained intact. The drift accumulations in front have nearly doubled; a gap of 100 feet in width was washed out in Cross-dike No. 3. The foot-mat on this dike was built but not sunk.

Baleshed dikes.—A gap of about 300 feet in length occurred in January by the breaking off of the piles by drift in the main dike between Cross-dikes No. 8 and No. 9. This gap has increased to about 1,000 feet in length, beginning 400 below Cross-dike No. 8 and extending below Cross-dike No. 9, which has been washed out. At this stage (23.5 feet) there is a considerable volume of water passing through this break. The maximum depth at the upper end is 15 feet, whence it gradually shoals to the lower end of the break.

This water flows to the left of Stack Island, and the gap is so located as to aid the river in its efforts to again form a channel behind the island. It is unfortunate for the success of the work that there are no funds available to repair this break.

The gap left in dike No. 11, and which was not closed on account of the stoppage of the work, has increased from 50 to 150 feet in width, due to the break in the main dike, to which reference has been made above.

Stack Island dikes.—After the completion of the cross-dike, it became necessary to make an opening through this dike in order to get material to Dikes 8 and 11, which had been ordered constructed. The abrupt suspension of all construction work prevented its closure. This gap has increased from 75 to 150 feet in width, due to the breaks mentioned above.

REVETMENT WORK.

Mayersville Island.—The effect of the last rise upon the revetment at the head of Mayersville Island has been to undermine the work at the extreme upper end. This undermining continued, caving begun and increased as the river fell, until it now extends from the head of the island down to a point about 500 feet above Range 53 (a distance of 3,400 feet). Above this point all the revetment has washed out. Opposite to where the upper end of the island was, the caving has extended back 600 feet. The present head of the island is 700 feet further down-stream than it was at the close of the work last season.

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About 46 per cent. of the revetment which was reported in fair condition October 1, 1884, has been destroyed. The caving will continue, unless arrested, as the main current of the river impinges directly upon the head of the island.

Pilcher's Point Revetment.—The revetment finished last season along Louisiana Bend caved in places during the high water. These caves have increased in size somewhat, and now aggregate about 30 per cent. of the entire work. No new breaks have occurred within the last two months, and in no place does the caving extend back more than 125 feet.

CHANGES IN THE CHANNEL.

Considerable caving has taken place on the right bank below the revetment work at Pilcher's Point, forcing the crossing lower down and inducing caving on the left bank where the current impinges between Range 30 and Range 34. The river again makes a crossing to the Louisiana side above the head of the Duncasby Dikes, and then deflects back again, striking the Mississippi shore between Wilderness Landing and the upper end of Mayersville Island, following along the face of the island it deflects back to the right bank at Longwood; thence along the Louisiana shore to Elton, where it again deflects to the left bank at Ben Lomond. From here the channel crosses to the Louisiana side at Stone's, following the shore to Wyley's, and again crosses back to the Mississippi shore at Shipland. At this point there are indications that the channel may divide, during low water, on each side of Ajax Bar, which, if such should be the case, would, in all probability, cause this crossing to be the shoalest on the reach. From here the channel follows the same course as last season to the head of Island 95. The channels for the approaching low-water season will be about the same as during the last low water, except, possibly, the change indicated at Ajax Bar.

During the low-water period of October, November, and December, soundings were taken on the two shallow crossings on the reach with the following results. These soundings were kept up during the high water of January and February, 1885:

Shallow crossings, Lake Providence Reach.

Date.	Lake Providence gauge-readings.	Least depth Stack Island crossing, channel, 1,000 feet wide.	Least depth Ben Lomond crossing, channel, 1,000 feet wide.
1884.	*Feet.*	*Feet.*	*Feet.*
October 10	14.8	24.5	15.0
October 20	13.7	26.0	24.0
October 30	12.0	24.5	22.5
November 10	11.1	23.0	26.0
November 20	7.25	21.0	17.0
November 29	6.58	19.0	16.0
December 9	7.83	20.0	18.0
December 19	11.00	23.5	19.0
December 30	12.00	21.0	20.0
1885.			
January 10	29.45	40.0	39.0
January 19	33.59	46.0	43.0
January 30	34.65	44.0	42.0
February 9	31.45	39.0	38.5
February 20	27.08	33.0	33.0
February 28	21.20	24.5	26.5

From the above it will be seen that improvement took place in channel depth in the latter part of 1884, when compared with the low water of August and September earlier in the season given below:

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Shallow crossings, Lake Providence Reach.

Date.	Lake Providence gauge-readings.	Stack Island, 1,000 feet channel, least depth.	Ben Lomond, 1,000 feet channel, least depth.
1884.	*Feet.*	*Feet.*	*Feet.*
August 9	15.5	18	24
August 19	12.6	14	12
August 30	8.9	10	14
September 9	9.1	14	17
September 19	6.6	17	11
September 30	5.8	15	11

From all indications there seems to be no reason to anticipate any decrease of depth in these two crossings during the coming low-water season, which, for the last two seasons, have been the shallowest places on the reach.

SURVEYS.

The work of the survey party has been the completion of the low-water survey of October, 1884, special surveys to determine the effects of the construction works, discharge measurements, slope observations, and the preparation of progress sketches.

Below is a summary of discharge observations taken at Wilson's Point, from October 1, 1884, to March 5, 1885:

Date.	Lake Providence gauge.	Area.	Mean velocity per second.	Discharge per second.
1884.	*Feet.*	*Square feet.*	*Feet.*	*Cu. Feet.*
October 21	13.90	115,404	3.442	397,225
November 25	6.84	86,448	2.929	253,207
1885.				
January 3	21.05	121,547	4.018	488,334
January 8	27.93	155,310	5.186	805,392
January 13	30.75	169,065	5.779	977,028
January 21	33.93	174,417	5.272	919,578
January 29	34.61	178,151	5.394	960,923
February 6	33.70	181,883	5.119	931,101
February 14	28.28	156,660	4.393	688,226
February 19	27.15	159,568	4.379	698,681
February 25	24.65	149,472	4.106	613,700
March 5	17.51	125,572	3.546	445,281

The highest gauge reading (Lake Providence gauge) was May 10, 1885—35.10 feet; lowest, December 14, 1884—5.50 feet.

SUMMARY OF WORK DONE.

Field work:		
Discharges obtained	number	14
Discharges computed	do	12
General slope taken	do	1
Shore line located	miles	65¼
Gauges tested and reset	number	55
Signals replaced	do	297
Ranges sounded	do	136
Leveling	miles	52.2
Crossings sounded	number	30
△ erected	do	10
Special surveys	do	15
Lines cleared	miles	19
Office work:		
Maps made	number	58
Tracings	do	61
Progress sketches	do	5

Copies of these maps have been forwarded to you from time to time.

Assistant Engineer Ture Lowegren died on March 17, of swamp fever.

The party was disbanded on the 20th.

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List of barges, pile-drivers, tow-boats, &c., constituting the floating property belonging to Lake Providence Reach.

Classification.	Number.	Dimensions.	Remarks.
		Feet.	
Tow-boats	4		Two with Missouri River Commission.
Graders	2	110 by 30	
Grader	1	80 by 16	Small.
	3		
Mattress-boat	4	160 by 30	
Do	2	200 by 30	
Do	1	149 by 49	Old.
	7		
Screen-boats	4	100 by 25	
Quarter boats	10	130 by 25	
Do	1	100 by 30	
Do	1	135 by 30	
Do	2	100 by 25	
Do	2	80 by 20	
Do	1	70 by 18	
	17		
Machine-shop boat	1	100 by 20	Old.
Do	1	211 by 35	New.
	2		
Carpenter-shop boat	1	211 by 25	
Dock	1	186 by 50	
Do	1	37 by 16	
Do	1	27 by 8	
	3		
Wharf-boat	1	100 by 24	
Derrick-boat	1	100 by 25	
Pump-boat	1	47 by 12	Steam.
Barges, decked	36	100 by 25	
Do	2	160 by 28	
Do	5	75 by 15	
Do	1	66 by 15	
Do	1	60 by 14	
	7		
Do	1	132 by 24	
Do	10	140 by 28	Do.
	56		
Pile-drivers	12	70 by 20	
Do	4	82 by 20	
	16		
Catamaran	1		
Calking flats	8	25 by 7	
Do	2	42 by 12	
	10		
Yawls	7		
Skiffs	59		
Coal-barges, open	4	120 by 26	Old.
Coal-barges, decked	12	120 by 26	Do.
Coal-boats	2	160 by 26	Do.
Total number pieces	211		

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Below is given the amount expended for labor and subsistence:

Classification.	Pay-roll.	Subsistence.	Total.
Dike party	$7,154 19	$2,202 15	$9,356 34
Bank revetment party	4,716 82	1,527 47	6,244 29
Survey party	5,808 32	611 26	6,419 58
Tow-boats	11,455 31	1,863 91	13,319 22
Care of fleet	21,225 26	3,821 60	25,046 86
Rock party, Arkansas City	6,667 89	1,494 00	8,161 89
	57,027 79	11,520 39	68,548 18
Services of the United States steamer Vidalia at Delta Point, to be deducted from the above	196 63	49 00	245 63
			68,302 55

The maximum number of men employed in any one month was 467; the minimum, 45.

AVERAGE COST OF SUBSISTENCE.

Cost of raw material, each ration	$0.289
Cost of each ration served	0.379
Cost of each ration served for each day's labor secured	0.435

WORK DONE.

Grading	cubic yards	6,675
Wattling built, 16,168 linear feet	squares	2,880.5
Woven mat built, 2,190 linear feet	do	2,190
Woven mat, sunk, 2,190 linear feet	do	2,190
Grillage built, 1,467 linear feet	do	621
Grillage sunk, 1,467 linear feet	do	621
Revetment built, 1,750 linear feet	do	1,072.17
Revetment rocked, 1,835 linear feet	do	1,119.32
Dike driven	linear feet	1,743
Piles driven	number	655
Braces put on	do	425
Stringers put on	do	237
Rock loaded	cubic yards	17,826.1

MATERIAL EXPENDED.

Piles	number	658
Braces	do	425
Stringers	do	237
Poles	cords	215.9
Brush	do	4,270.8
Iron and spikes	pounds	28,561
Lumber	feet	47,675
Oakum	pounds	1,060
Stone	cubic yards	2,057.1
Coal	bushels	74,517
Wire	pounds	18,810

In compliance with instructions received on December 31, 1884, all construction work was suspended except the loading of stone by the force at Arkansas City for securing the unfinished revetment at Pilcher's Point, the men discharged, and the fleet laid up at Wilson's Point, only sufficient men being retained to care for the property. The force at Arkansas City was disbanded on January 20, 1885.

Very respectfully,

ARTHUR HIDER,
Assistant Engineer in charge.

Capt. CLINTON B. SEARS,
Corps of Engineers, U. S. A.

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APPENDIX K.

REPORT OF MAJOR AMOS STICKNEY, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 17, 1885.

SIR: In compliance with your request I have the honor to submit the following report of operations in the Fourth District of the Mississippi River, to include the time from last annual report, October 1, 1884, to June 30, 1885. The works in this district are as follows, viz:

Construction and repair of levees.

Improvement of Mississippi River at Natchez and Vidalia, Miss. and La.

Improvement of mouth of Red River and rectification of the Red and Atchafalaya at mouth of Red River.

Improvement of the harbor at New Orleans, La.

Survey of Cubitt's Gap and vicinity.

LEVEES.

On the 27th of September, 1884, proposals were received for work on levees and the following were accepted:

Locality.	Names of bidders.	Number of yards.	Price per yard.
			Cents.
Point Pleasant Levee	James M. Searles	22,000	17½
Shipp's Bayon to Hard Times Levee	Dabney & Gray	38,000	25
Bondurant Levee	W. O. Flynn	35,000	17
Kempe Crevasse Levee	Hughes & McGinty	25,000	17
Lake Concordia Levee	Dabney & Gray	31,000	17½
Hardscrabble Levee	Thomas O'Malley	75,000	24½

Contracts were made as soon as possible, and by October 10 nearly all the parties were at work. Searles having failed to make contract under the conditions imposed, Hughes & McGinty, the next lowest bidder, took the work at 18¾ cents per yard. With the experience of past years to guide us, it was considered essential to make more rigid contracts and specifications in order that more perfect control of the work might be had, especially with regard to the number of men employed on each levee. With this in view each contract contained a clause specifying the number of men that should be engaged in the actual work of levee building, exclusive of the auxiliary force necessary for the work in camp, and in order to enforce this clause a provision was made by which men could be placed on the work at the contractor's expense. These new forms of contract and specifications proved to be most excellent in keeping the contractors up to the work. In only one case was it necessary to put men on at the contractor's expense, and that only for a few days. At Kempe Levee work was continued and finished by hired labor. Late in the season, December 19, 1884, an allotment of $8,710 was made by the Commission for completing Evergreen Levee. This work was commenced by the authorities of Tensas Parish, but proved to be too extensive for the means at their disposal. A contract was made with Dabney & Gray, at 22½ cents per yard, for doing this work, which they completed March 2. All of the levee work which was undertaken this year was completed in good season, with the exception of a portion of the levee at Hard Times, which continued to sink as it was built up, and is only just finished. A short stretch of the Kempe Levee has also sunk so as to be in a dangerous condition in case of a high flood. Exhaustion of funds prevents any work being done at present, and there is no likelihood of danger until next spring, before which time funds may be available for placing the bank in good condition. Considerable repair work has been done on the levee built by the Government below Red River.

This work being scattered over a considerable line, and consisting mostly of strengthening weak places and general patching, was done by hired labor, it being difficult to specify it and get reasonable bids from contractors.

In connection with the building of Kempe Levee, a survey was made to determine the practicability of constructing another line in front of the lakes in case the present levee should cave into the river, and for the purpose of estimating the cost of protecting the banks. This bend is rapidly deepening by the caving of the bank.

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During the year about 9 miles of levee have been built, closing forty gaps, and requiring something over 300,000 yards of embankment. The line of levees in the Fourth District is now in pretty fair condition, with the exception of a deficiency in height. The only gaps are:

	Feet.
Diamond Bend to New Carthage	50,000
Bougere Crevasse	23,400
Black Hawk to Red River	90,000
Morganza	6,000

On January 4, 1885, the store-house at Hardscrabble Levee, containing the tools and outfit used on that levee, was destroyed by fire with a considerable quantity of the contents. The caving bank at Kempe Levee threatened to fall into the river with the property stored at that point. Authority was, therefore, asked and received to construct a store-house on the high ground in Giles Bend just above Natchez, which was under rental in connection with the improvement in that vicinity. The store-house was constructed, and all property pertaining to the levees carefully stored under the charge of watchmen, who also have the care of the Red River and Natchez property. For details of levee work reference is made to the report of Assistant Engineer H. S. Douglas, appended.

SURVEY OF KEMPE BEND.

The survey of Kempe Bend, in Tensas Parish, Louisiana, called for by the resolution of the Commission of May 12, 1884, was completed during the fall and winter he object of this survey was to ascertain approximately a line upon which a new levee could be built and the cost of protecting the caving bank, and was instigated by a petition from the police jury of Tensas Parish, who were alarmed at the rapid caving of the river bank and the possibility that a new line of levee would soon be required, and that it would not be practicable to construct a new line without falling back of Lake Saint Peter. The survey shows that a line can be constructed in front of the lake, with a fair location. A comparison of the line of the river bank with the lines of other years back to 1866, shows a very serious caving, about 5,500 feet, and increasing in rapidity. A little study of the map presents some startling figures. Here in one short reach of the river less than 6 miles in length 76,000,000 square feet of earth, with an average depth of, say, 100 feet, making 7,600,000,000 cubic feet of earth, have been moved by the river in nineteen years; an average of 400,000,000 cubic feet per year. The prevention of this caving, by works of bank protection, would permit a vast amount of energy to be applied to the maintenance and deepening of the channel, and an ultimate lowering of the water surface, which would, in my opinion, if extensively carried out in connection with works for contracting the channel at a few points, solve all the questions of improvement of navigation and prevention of overflow, rendering levees almost unnecessary above the mouth of Red River, in a comparatively short space of time. An inspection of the above figures should convince the most skeptical that bank protection is the great necessity in the work of improving the river.

The cost of protecting the bank in this bend with a system of submerged spurs is computed at $250,000. There are 25,000 feet requiring protection, and it is estimated that spurs at a cost of $10,000 each, placed at intervals averaging 1,000 feet in length, will be sufficient for the purpose. If the mattress system is adopted, the cost, at $18 per foot, would be $450,000. The cost of a new levee around Kempe Bend is estimated at about $199,500, and at present rate of caving would have to be built in about two or three years, some of it sooner. As the protection of the bank at this point would not only save the cost of the new levee, but also be a part and parcel of the work of river improvement, I would strongly recommend that the work be commenced as soon as practicable.

The report of Assistant Engineer H. S. Douglas on the survey is appended.

IMPROVEMENT OF MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA.

No work has been done in this vicinity, owing to the lack of funds. The method of improvement recommended in previous reports to the Commission contemplates the protection of the caving banks by means of submerged sloping spurs placed at intervals to be determined as the work progresses, but assumed for estimate of cost at 1,000 feet.

The estimate of cost is $600,000.

To prevent the flow of flood water across the neck of land between Giles and Cowpen bends, it is proposed to construct a levee at an estimated cost of $100,000.

This makes the total estimate $700,000. If it became necessary to protect the caving banks by mattress work the cost for this item would approximate $1,040,000.

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IMPROVEMENT OF MOUTH OF RED RIVER AND RECTIFICATION OF THE RED AND ATCHAFALAYA AT MOUTH OF RED RIVER.

At date of last annual report, October 1, 1884, the plant was at work in Old River keeping a navigable channel between the Mississippi and the Atchafalaya.

On October 1, the Mississippi reached its lowest stage at Red River Landing, being 6.3 feet on the gauge, and on October 3, began to rise. The channel was constantly maintained by hard work and various devices. The scouring by the use of the propellers of tugs lashed to a steamboat was not successful, except at a point near the Atchafalaya where a comparatively short bar existed, with deep water just beyond it. It became necessary to construct temporary spur-dikes of willow brush along one reach, and to drag a scraper hanging from the bow of a stern-wheel steamer at other places. The temporary spurs, I believe, offer the best method of keeping the channel open during a season at the least cost, if placed in time to take advantage of the current. They should be assisted by a stern-wheel steamer with a scraper. On October 8 operations were suspended, and on the 10th the tugs were passed through Old River with considerable difficulty, the surface slope of the water being 7.5 feet in 6 miles. The water did not reach as low a stage at Barber's Landing as it did in the previous year, and there was less sloughing of the banks. The channel remained in good condition till about November 27, when the Mississippi had again fallen to 7.65 at Red River Landing. Being apprehensive of further trouble I dispatched the steamer Annie Kelley, belonging to the New Orleans Harbor work, to resume operations with the drag scraper. She worked from November 30, to December 8, when the rising river made it unnecessary to continue longer.

No work has yet been done in this vicinity for a permanent amelioration of the difficulties of navigation which recur almost annually, and to prevent a further enlargement of the Atchafalaya.

The estimates of cost of the work proposed by me in my report of December 15, 1883, which were published in the last annual report of the Commission, were so distorted by mistakes in making extracts and by printers' errors, that I consider it proper to restate them here, as follows, viz:

Atchafalaya River work	$576,150
Upper Old River work	438,130
Lower Old River work	48,000
	1,062,280
Add 10 per cent. for contingencies	106,228
Total	1,168,508
For temporary work in Lower Old River to keep a channel while permanent work is progressing, and part of which would be utilized in the above item for Lower Old River	75,100
Add 10 per cent. for contingencies	7,510
	82,610
The entire cost would then be	1,251,118

And not $2,151,660 as it appeared in the report of the Commission.

A plan for the work in this vicinity was prepared by the Commission and published in their last annual report, but no instructions in reference thereto have been received by me.

For details of the work performed at the mouth of Red River, reference is made to the report of Assistant Engineer A. O. Wilson, appended.

PLAQUEMINE ROUTE.

The estimates for opening a navigation route to the Atchafalaya and Red rivers by way of Bayou Plaquemine having been presented to the Commission December 17, 1883, the maps were worked upon only at such times as assistants could be spared from other more pressing work, the assistant in charge of the survey having died in the field. Copies of the maps were forwarded to the secretary of the Commission March 2, 1885.

There is no question of the feasibility of establishing this route as marked on the map. The location and drawings of locks, and location of excavation work, as presented on the maps, were made for the purpose of estimating cost only. The inauguration of any work would, of course, necessitate further study and probable changes.

The report of Assistant Engineer A. O. Wilson, relating to the maps, plans, &c., is appended.

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IMPROVEMENT OF HARBOR AT NEW ORLEANS, LOUISIANA.

At the date of last annual report, October 1, 1884, work was in progress in that part of the harbor designated as Gouldsboro' Bend. The construction of the first submerged spur had been commenced. The work continued until November 28, when it became necessary to suspend operations on account of the exhaustion of funds. Two spurs were completed and one spur about half built. Nearly all the stone for ballast, iron rods for mattress and crib work, and other material, except brush, are on hand for the completion of the six spurs which are to form the protection for this bend. It was originally intended to build the spurs so as to project horizontally 50 feet out into the river at low-water surface, but the new survey of the bend developed the fact that so constructed the spurs would be higher than was considered advisable in the experimental beginning of the work; the slope of the spurs was therefore started immediately from the low-water shore-line. They can be carried out into the river hereafter if it should be deemed advisable.

The effect of this work cannot be noted until the falling of the river diminishes the current sufficiently to permit accurate soundings to be taken in depths of 100 feet. The direction and velocity of the current have been favorably affected by the spurs, and, as far as can be noted, the structures have suffered no damage. The cost of this work has been about $12,500 for each spur as completed. This can and will be very considerably reduced in future work, as perhaps as much as one-quarter of the cost has been for experience in learning how to construct and sink the mattresses and cribs exactly in place in depths which at some points reach over 100 feet. The revised estimated additional amount needed for completion of work in New Orleans Harbor is as follows:

Carrollton Bend (mattress project)	$158,600
Gouldsboro' Bend (completion)	35,000
Gretna Bend	64,200
Bend above Gretna to a point nearly opposite the city park, right bank	396,600
Total	654,400

For details of the work reference is made to the report of Assistant Engineer W. G. Price, appended, and plates.

SURVEY OF CUBITT'S GAP AND VICINITY.

The survey of Cubitt's Gap, for which an allotment was made, was attempted in January, 1883. Owing to the dense and continuous fogs, the party accomplished scarcely any work, and was withdrawn to await a better opportunity. The cost of the party consumed nearly half of the allotment and application was made for an additional sum. This not having been granted as yet, the survey cannot be resumed.

A survey of the Mississippi River in the vicinity of the gap was made by the party stationed at South Pass under the direction and by the kindness of Maj. W. H. Heuer, Corps of Engineers, U. S. A., a platting of which will be incorporated in the map of the survey.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers, U. S. A.

Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A., President Mississippi River Commission.

Construction and repair of levees, Fourth District. Improving Mississippi River, no limit.

ATCHAFALAYA FRONT.

Act of Congress, passed August 2, 1882, for improving Mississippi River, no limit:

November 23, 1882, allotted	$110,000 00
Expended to June 30, 1883	97,525 42
Balance on hand July 1, 1883	12,474 58
Expended to June 30, 1884	12,474 58

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Act of Congress approved January 19, 1884, for improving Mississippi River, no limit:		
March 25, 1884, allotted		$5,000 00
Expended to June 30, 1884		5,000 00
March 28, 1884, allotted		4,000 0
Expended to June 30, 1884		4,000 00
April 1, 1884, allotted		15,000 00
Expended to June 30, 1884		4,602 73
Balance on hand July 1, 1884		10,397 27
Expended to June 30, 1885		9,901 20
Balance on hand July 1, 1885		496 07
April 12, 1884, allotted	$12,000 00	
March 3, 1885, transfer to Tensas front	3,000 00	
Expended to June 30, 1885	0 00	
Balance on hand July 1, 1885		9,000 00
Total balance on hand July 1, 1885		9,496 07

TENSAS FRONT.

Act of Congress passed August 2, 1882, for improving Mississippi River, no limit:		
November 23, 1882, allotted		$426,160 00
Expended to June 30, 1883		228,520 31
Balance on hand July 1, 1883		197,639 69
Expended to June 30, 1884		197,637 94
Balance on hand July 1, 1884		1 75
Expended to June 30, 1885		1 75
Act of Congress approved January 19, 1884, for improving Mississippi River, no limit:		
February 27, 1884, allotted		5,000 00
Expended to June 30, 1884		5,000 00
March 24, 1884, allotted		10,000 00
Expended to June 30, 1884		10,000 00
March 28, 1884, allotted		6,000 00
Expended to June 30, 1884		141 12
Balance on hand July 1, 1884		5,858 88
Expended to June 30, 1885		5,858 88
Act of Congress approved July 5, 1884, for improving Mississippi River, no limit:		
August 5, 1884, allotment		90,000 00
Expended to June 30, 1885		89,388 24
Balance on hand July 1, 1885		611 76
December 19, 1884, allotted		8,710 00
Expended to June 30, 1885		8,710 00
March 3, 1885, allotted transfer from Atchafalaya front		3,000 00
Expended to June 30, 1885		3,000 00
Total balance on hand July 1, 1885		611 76

SURVEY UNLEVEED FRONTS, FOURTH DISTRICT.

November 20, 1882, allotment from appropriation for improving Mississippi River, no limit; for survey unleveed fronts, Fourth District:		
Act passed August 2, 1882		$1,000 00
Expended to June 30, 1884		902 12
Balance on hand July 1, 1884		97 88
Expended to June 30, 1885		97 88

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IMPROVING MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA.

Aggregate expenditures on work before it was placed under the Commission		$81,747 96
Balance on hand July 1, 1882		8,252 04
Disbursements since work was placed under the Commission:		
Expended to June 30, 1883		2,343 37
Balance on hand July 1, 1883		5,908 67
Expended to June 30, 1884		1,847 25
Balance on hand July 1, 1884		4,061 42
Expended to June 30, 1885		2,435 47
Balance on hand July 1, 1885		1,625 95

MOUTH OF RED RIVER, LA.

IMPROVING MOUTH OF RED RIVER, LOUISIANA.

Aggregate expenditures on work before it was placed under the Commission		$99,187 60
Balance on hand July 1, 1882		90,812 40
Disbursements since work was placed under the Commission:		
Expended to June 30, 1883		37,663 73
Balance on hand July 1, 1883		53,148 67
Expended to June 30, 1884		34,844 98
Balance on hand July 1, 1884		18,303 69
Expended to June 30, 1885		18,303 69

MOUTH OF RED RIVER, LA.

IMPROVING MISSISSIPPI RIVER, NO LIMIT.

August 5, 1884, allotment from appropriation for improving Mississippi River, no limit, for improving mouth of Red River, Louisiana:		
Act approved July 5, 1884		$12,290 00
March 3, 1885, transfer to harbor at New Orleans	$900 00	
Expended to June 30, 1885	7,573 92	
		8,473 92
Balance on hand July 1, 1885		3,816 08

BONNET CARRÉ CREVASSE.

November 16, 1882, allotment from appropriation for improving Mississippi River, no limit; for closing Bonnet Carré Crevasse:	
Act passed August 2, 1882	$15,000 00
February 22, 1883, expended in one payment	15,000 00

IMPROVING HARBOR AT NEW ORLEANS, LOUISIANA.

Aggregate expenditures on work before it was placed under the Commission		$112,206 19
Balance on hand July 1, 1882		147,793 81
Disbursements since work was placed under the Commission:		
Expended to June 30, 1883		5,167 53
Balance on hand July 1, 1883		142,626 28
Expended to June 30, 1884		55,163 82
Balance on hand July 1, 1884		87,462 46
Expended to June 30, 1885	$87,006 35	
Covered into Treasury	123 42	
		87,129 77
Balance on hand July 1, 1885		332 69

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Act of Congress approved July 5, 1884, for improving Mississippi River, no limit:		
February 27, 1885, transfer of allotment for Red River to New Orleans Harbor	$900 00	
Expended to June 30, 1885	636 12	
Balance on hand July 1, 1885		$263 88
Total balance on hand July 1, 1885		596 57

OBSERVATIONS AT CARROLLTON, LOUISIANA.

November 19, 1882, allotment from appropriation for improving Mississippi River, no limit; for observations at Carrollton, La.:		
Act passed August 2, 1882		$3,000 00
Expended to June 30, 1883		2,744 26
Balance on hand July 1, 1883		255 74
Expended to June 30, 1884		255 74
June 25, 1883, allotment from appropriation for the Mississippi River Commission:		
Act approved March 3, 1883, for observations at Carrollton, La.		1,500 00
Expended to June 30, 1883		491 00
Balance on hand July 1, 1883		1,009 00
Expended to June 30, 1884		963 11
Balance on hand July 1, 1884		45 89
Expended to June 30, 1885		45 89

CUBITT'S GAP AND VICINITY.

September 17, 1882, allotment from appropriation for improving Mississippi River, no limit; for survey of Cubitt's Gap and vicinity:		
Act passed August 2, 1882		300 00
Expended to June 30, 1883		137 14
Balance on hand July 1, 1884		162 86
Balance on hand July 1, 1885		162 86

Approximate value of plant belonging to the United States and used upon the construction and repair of levees, Fourth District.

Class of property.	Approximate value June 30, 1885.
Tools and appliances	$2,000 00
Office furniture	400 00
Surveying instruments	60 88
Miscellaneous	1,162 87
Total value	3,622 75

Approximate value of plant belonging to the United States and used upon the improvement of harbors of Natchez and Vidalia.

Class of property.	Approximate value June 30, 1885.
Tools and appliances	$250 00
Office furniture	15 00
Miscellaneous	6 50
Total value	271 50

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Approximate value of plant belonging to the United States and used upon the improvement of mouth of Red River.

Class of property.	Approximate value June 30, 1885.
Steam-launch Ruby	$3,500 00
Two quarter-boats	3,245 40
Six skiffs and row-boats, &c	135 00
Tools and appliances	55 00
Office furniture	115 00
Surveying instruments	970 75
Miscellaneous	491 09
Total value	8,512 24

Approximate value of plant belonging to the United States and used upon the improvement of New Orleans Harbor.

Class of property.	Approximate value June 30, 1885.
Steamer General Newton	$12,900 00
Steam-tug Tilda	4,500 00
Steam-launch Alaska	2,700 00
Fifteen barges	23,700 00
One skiff, row-boat, &c	25 00
Tools and appliances	1,900 00
Office furniture	25 00
Surveying instruments	11 11
Miscellaneous	69 67
Total value	45,830 78

Approximate value of plant belonging to the United States and used upon the survey of unleveed fronts, Fourth District.

Class of property.	Approximate value June 30, 1885.
Tools and appliances	$0 60
Miscellaneous	10
Total value	70

Approximate value of plant belonging to the United States and used upon the observations at Carrollton, La.

Class of property.	Approximate value June 30, 1885.
Tools and appliances	$0 80
Office furniture	80
Total value	1 60

Approximate value of plant belonging to the United States and used upon the survey of Cubitt's Gap and vicinity, June 30, 1885: No property.

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K 1.

REPORT OF ASSISTANT ENGINEER H. S. DOUGLAS UPON CONSTRUCTION AND REPAIR OF LEVEES IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 16, 1885.

SIR: I have the honor to submit the following report on the construction and repair of levees from October 1, 1884, to the close of the fiscal year ending June 30, 1885:

At date of last report bids for work on the following levees had been opened:

	Cubic yards.
Point Pleasant, about	22,000
Shipp's Bayou to Hard Times, about	38,000
Bondurant, about	35,000
Kempe Crevasse, about	25,000
Lake Concordia, about	31,000
Hardscrabble, about	75,000

It was stated that the amount in Lake Concordia Levee was liable to be materially increased, as the flood of 1884 had proved it to be entirely too low, and it was proposed, if possible, to raise it about 2 feet, with a corresponding increase of cross-section.

Awards based on the bids received were duly made and approved, and by October 10 embankment construction was in progress on nearly all the levees. The hard experience of two previous years was brought to bear upon the work. New and better specifications had been adopted and some changes were made in the method of supervising levee construction.

A rigid enforcement of the various contracts soon brought any of the contractors who were not disposed to prosecute the work with due diligence to terms, and the result was that the work progressed smoothly and with scarcely an incident worthy of note, until the various levees were completed, frequently in advance of the contract time.

The working season just past may be said to have been a good one.

The supply of labor was plentiful, and, until the middle of December, the weather favorable. There was but little sickness among those employed, probably owing to the dryness of the season. The injury to levees caused by traffic over them has been mentioned in previous reports, and in order to prevent this, at least until the embankments were thoroughly grassed and settled, barbed-wire fences were built across the levees. These fences extended from the foot of the slope on the land side to the foot of the slope on the river side, and were built at intervals of about 500 feet.

I give progress on each levee:

TENSAS FRONT.

Point Pleasant.—The lowest bidder for this work failed to qualify, and ultimately the contract was awarded to the next lowest bidder. This entailed some delay, and the work was not commenced until about November 17. It was then, however, prosecuted with vigor, and the work, consisting of gaps in the new levee caused by the flood of 1884, completed and received January 30.

SHIPP'S BAYOU TO HARD TIMES.

Embankment construction was commenced about October 15, and all of the levee except the "sinking portion" was completed and received December 31. This sinking portion has been mentioned in previous reports as giving a great deal of trouble. It was hoped that the sinking had ceased and a solid foundation been reached, but this hope was disappointed. A force was kept at work on this sinking part until lack of funds necessitated a suspension of operations, when final settlement was made with the contractors. Later on a transfer of funds was made from the Atchafalaya Front, and arrangements made for the continuance of the work, using wheel-scrapers and teams, as the earth had to be hauled a long distance. Slow progress was made towards completion, as the sinking continued. Finally, on June 20, the sinking having apparently ceased, work was suspended. It is not improbable next season's high water will cause the sinking to re-commence.

Evergreen.—This levee connects the United States Hard Times and Hardscrabble levees. Its construction was undertaken by the parish of Tensas. Their funds were exhausted when about two-thirds of the levee had been built, and it was feared that there would be a gap in the line of levees at this point. The matter having been

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brought to the attention of the Commission, they made an additional allotment to construct that portion of the levee which the parish was unable to build. Notification of this allotment was received December 24, and authority was given, on account of the lateness of the season, to ask for informal bids. This was done, and the contract awarded to the lowest bidder. Embankment construction was commenced January 10. An early rise of the river brought it over the banks and against the levee before its completion, and a portion of the river base was thrown up to keep the water out. Rainy weather interfered considerably with the progress of the work, but the levee was finally completed March 2.

Hardscrabble.- Work on this levee by hired labor had been in progress from the annulment of the original contract until the high water of 1884. The overflow of that year having caused a heavy deposit in the swamp through which the levee passes, and changed to some extent the character of the work, it was thought a favorable bid could be obtained. It was accordingly advertised, and awarded to the lowest bidder. Embankment construction commenced on October 10, with a very small force. Some trouble was experienced in getting a proper force placed upon the levee, and it was only when extreme measures were resorted to that a sufficient number of men were placed upon the work. After this no further trouble was experienced, and rapid progress was made until the completion of the levee, December 31.

Bondurant.—The levee previously built by the United States at this point caved into the river for a length of about 1,200 feet on the subsidence of the high water of 1884, and a new line, or run-around, was staked out to close the gap. Work was commenced about October 8, and pushed with energy until completion of the levee, December 20. At the time when the levee was located the point at which the lower wing joined the existing levee was 1,000 feet from the river bank. Since the completion of the run-around the caving has been extraordinarily rapid. On May 11 an inspection was made, when it was ascertained that the point before mentioned was but 175 feet from the edge of the bank, which was still caving rapidly. It is almost certain that a portion of the old and new levees will cave into the river, and occasion a gap in the line of levees at this point.

Kempe Levee.—Previous to the opening of bids for work on the other levees, preparations had been made for the resumption of work on this levee by hired labor. On October 1, embankment construction was commenced. The rather severe experiences gained during the winter of 1884–'85 were borne in mind, and the result was an improved system and organization. Rapid and satisfactory progress was made, and this levee, which had given so much trouble, was completed January 10. A small force was kept at work on a portion of the levee across Potter's Slough, where the embankment sinks as at Hard Times. Lack of funds caused a suspension of work at this point on February 11.

Additional work is required at this place, as it is now the weakest point on the levee.

Kempe Crevasse.—This was a gap in the finished portion of the new Kempe Levee occasioned by the breaking of the protection levee during the flood of 1884. A run-around was staked out to close it, and work by contract commenced October 8. Rapid progress was made and the levee was finished November 29.

Lake Concordia.—This long line of levee was completed by the United States in the spring of 1883. The flood of 1884 breached it at several places, the breaks being caused by the water running over the levee. Work by contract for the closure of these gaps was commenced October 10. The low bids received on the various levees left an unexpectedly large balance of available funds, and it was decided to apply them, so far as they would go, to the enlargement of the existing levee, it evidently being too low. This was done accordingly, and all work at this levee for which funds were available was completed and received January 17.

ATCHAFALAYA FRONT.

The flood of 1884 had damaged some of the United States levees on this front to a considerable extent. The work necessary for their repair was not of a character that could be done by contract, and authority was obtained to do the work by hired labor. An overseer was placed in charge of a small force and all of the necessary repairs made.

At Red River Landing three bad sloughing places and about 1,000 feet of the levee that had been badly wave-washed were repaired in a substantial manner. At the Raccourci Levee a short piece of new embankment was built to cut off a bad crayfish hole, and numerous sloughing places and wave-washes were repaired.

At the Pointe Coupée (Scott) Levee the sloughing places were repaired in a thorough manner, and the sinking place across the old lake was raised. The result of the work has been to place the United States levees on this front in first-class condition.

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KEMPE BEND SURVEY.

A resolution of the Commission passed at their meeting on May 12 directed that a survey of the Kempe Bend be made, and that all information accessible concerning previous bank lines and surveys be added to the survey; also an estimate of the cost of the necessary revetment. The survey has been made accordingly, the information collected, the survey platted, and the report, with estimate, submitted.

There is little if any variety in levee work under ordinary circumstances, and my previous reports give about all the special features I have noticed. The work is chiefly of an administrative character so far as the assistant in general charge is concerned. I will state, however, that a report gives but a faint idea of the incidents, details, and responsibilities of work of this character. The flood line of the high water of 1885 has been unusually low, and the new levees have scarcely been put to a test. Before the next flood can reach them they will have had ample time to become well sodded and settled.

All of the property, tools, utensils, &c., that were acquired during the continuance of levee work by hired labor have been transferred to a place of safe-keeping at the Government landing situated on the left bank of the river about 15 miles above Natchez, Miss. At this point a suitable storehouse has been built for the accommodation of the property, which has been thoroughly overhauled, painted, repaired, and otherwise placed in as good condition as possible.

SUMMARY OF WORK.

Actual length of levees built, in feet	46,340
Number of gaps closed	40
Number of cubic yards earth placed in embankment (approximate, on account of repair work and sink at Hard Times, which could not be measured)	311,000
Approximate number of men employed per day when work was in progress on all levees	1,500

This work, together with what has been done by the State and parishes, has resulted in the closure of all gaps on the Tensas Front in the fourth district, except Diamond Bend, Bougere, and Black Hawk, to Red River. On the Atchafalaya Front all the United States levees have been placed in good condition, and the only gap on that front is the Morganza Crevasse. In general terms it may be stated that the levees throughout the district are in more perfect condition than they have been at any time for the past twenty years. It is gratifying to be able to make this statement, more especially as it is likely to be some time before work of this character is resumed by the General Government.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

K 2.

REPORT OF ASSISTANT ENGINEER H. S. DOUGLAS UPON THE SURVEYS IN THE FOURTH DISTRICT.

SIR: I have the honor to submit the following report on the survey of the Kempe Bend, Tensas Parish, Louisiana.

The survey was made in accordance with a resolution of the Mississippi River Commission, passed at their meeting May 12, 1884, providing that the survey be made and that all information accessible concerning previous bank lines and surveys be added to the survey; also, an estimate of the cost of the necessary revetment.

The field work of the survey was commenced November 21, 1884, and completed January 30, 1885. The work done consisted of a main traverse line on true meridian the full length of the bend, following the general course of the new levee; a shore or bank line connected with either end of the main traverse line; five lines of levels across the country about 4,000 feet apart, at nearly right angles to the river, extending back 10,000 feet from the main traverse line, and carried out to the river bank, where they were prolonged across the river by soundings. Data for the platting of of old bank lines and levees was obtained from the office of the Louisiana State Board of Engineers. That portion of the Mississippi River covered by the survey and known as the Kempe Bend is about 28,000 feet in length, and at high water, when the

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sand bar or island is covered, has a width of about 9,000 feet. In 1866 there were no indications of a bend at this place, as the river then flowed through an almost straight channel with a uniform width of about 4,000 feet. On old maps this portion of the river is delineated as a straight reach instead of a bend. In 1867 the Davis-Bend cut-off made at a point about 36 miles above. This shortened the river temporarily about 20 miles. The rapid caving at Kempe, and in fact all along the front of Tensas Parish, may be traced to this cause.

Between 1866 and 1885 the survey indicates that the river by caving its banks has destroyed 76,000,000 square feet, 1,747 acres of land. To accomplish this it has caved back at the deepest part of the bend a distance of 5,500 feet, destroyed the original comparatively high bank and eaten its way back into a low swamp, where levees of excessive height are now required to restrain the river and prevent an enormous escape of water from the channel. Owing to the rapid caving of the bank these levees are soon destroyed by the encroachments of the river, and new and expensive embankments are required.

Residents of the locality state that in the last twenty years $750,000 have been expended on levees in this bend.

So far as can be seen at low water the bank throughout the Kempe Bend is generally composed of a light sandy loam, which offers but little resistance to the current, and caving is continuous, both at high and low stages of the river. While the survey was in progress a deep hole was discovered in the river channel on one of the lines of soundings. In going over the same locality a few weeks after no trace of it could be discovered. This would indicate that the river bed is also composed of sand or some other material offering but little resistance to the scouring action of the water. The lines of levels which were run across the country indicate that the general elevation of the swamp behind the present levee is but little lower than where the present levee stands. While, therefore, it is not impossible to build another levee within a reasonable distance back of the present one, it will be a very expensive and difficult undertaking.

As directed, I submit the following approximate estimate for the protection of the existing bank and the prevention of further caving by means of submerged spur-dikes. The length of bank requiring protection at present is 25,000 feet, and with submerged spurs similar to those used in the improvement of New Orleans Harbor, located at intervals of about 1,000 feet, it is thought the desired result will be obtained. These spur-dikes are estimated to cost $10,000 each, or a total of $250,000 for the twenty-five estimated to be required for the protection of the bank in the Kempe Bend.

Should the present levee, recently completed by the Government, be destroyed by the caving of the bank a new levee on what appears to be the most feasible and safest line would be 30,000 feet long and with a grade 2 feet above the high water of 1884, 8-foot crown, and 3 and 3 to 1 slopes, would contain 665,000 cubic yards. Owing to the height of the bank and the low badly drained swamp through which the greater portion of the levee would be built, it would not be safe to estimate less than 30 cents per cubic yard as the cost of construction. At 30 cents 665,000 cubic yards would amount to $199,500. From present indications a portion of this levee will be required at the lower end of the Kempe Bend in a short time.

An inspection of the plat of the survey is of interest as showing the great changes that have taken place in the river at this locality. This plat is not completed in time to accompany this report, but will be finished in a few days.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

K 3.

REPORT OF ASSISTANT ENGINEER A. O. WILSON UPON IMPROVEMENT OF THE MOUTH OF RED RIVER.

NEW ORLEANS, LA., *June* 15, 1885.

MAJOR: I have the honor to submit to you the following report on work done in the improvement of the mouth of the Red River, Louisiana, from October 1, 1884, the date of the last annual report to the "Commission," to date.

The Mississippi River had reached its lowest reading for the year on the Red River Landing gauge on October 1, being 6.3 feet. The river rose steadily from the 3d of October; it was necessary to continue the construction of the brush-dams perpendicular to the line of the channel in Lower Old River, on both sides, in order to scour

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out the channel to its connection with the deep water at the head of the Atchafalaya River. The two propeller tugs were laid up at this point awaiting water sufficient to take them through Old River to the Mississippi, which it was an object to do, in order to return them to their owners at the earliest possible date. The force of twenty laborers and the small stern-wheel boat May Fisher were kept at work on the dams until October 7. The construction of the dams was of necessity very light, consisting of willow brush laid between two rows of poles driven down into the mud with a maul; the brush was weighted down with bags filled with sand. The dams could not be carried out far enough from the banks to create a channel for more than 500 feet below them, after which distance the current would spread out again and allow the hard sand lumps to form and obstruct navigation, whereas the channel between the dams was uniform in width and depth, with the bottom quite smooth. What caused these hard sand lumps in that part of the channel known as the Chandler reach, I cannot definitely state. Above Chandler's light we have sloughs in the banks, with mud lumps in the channel, and on the dry bar forming the low-water bank there are gas and water jets. Where the sand lumps are, no signs on either bank are visible of any disturbance, but parallel to the channel, on the north side of the dry bar, there is a large lake of water that at times is left standing considerably higher than the water in the channel. It is possible that this water may find its way through the bar, and, springing up in the bottom of the river, be the cause of the lumps, the concentrated current between the brush dams having power enough to scour out the sand lumps as fast as they can form. The river did not fall as low as last year by 2 feet on the Barbie's Landing gauge, 1.7 feet, on October 3, being the lowest reading. At this time we had a depth of 6 feet in the channel. I am satisfied that even had the water fallen as low as it did in 1883 we should have been able to maintain the channel by extending the dams. The operations of the season, though carried on at a little over half the expense of previous years, was successful, navigation having been kept open continuously for stern-wheel boats. This method, so successful this low-water season, cannot be relied upon always. The condition of things in general was more favorable for keeping a navigable channel open between the Mississippi and the Red and Atchafalaya rivers than in 1883. The current flowed in one direction without change from August 7 up to and after the suspension of operations. The sloughings or subsidences of the banks were not so large as those of last year. From the Mississippi to the Crossing there were slight subsidences on both banks for the whole distance. On the Atchafalaya side of the Crossing, near Chandler's light, there was a very large and remarkable subsidence on the main-land bank close under the high-water bank, and an enormous lump of mud came up, nearly blocking up the whole river; in fact, it only left a crooked channel 25 feet wide at the water surface. The peculiar feature of this slough was that the mud-flat, 300 or 400 feet in width, between the subsidence and the water's edge remained without the slightest sign of any disturbance having taken place. On the opposite side, for some distance above and below, the bar was all broken up in small perpendicular breaks, showing subsidence extending back from the water's edge for 300 feet. In this portion of the dry bar there had been gas and water jets which, after they had expended themselves, left a large shallow hole with a small deep round hole in the center. At Barbie's Landing only a slight settlement in the bank was evident.

On October 8 all the laborers, and the small stern-wheel boat May Fisher that had been used for towing willows and transporting the men, were discharged.

The Menge dredge was turned over to her owner October 8. The working of this dredge proved a failure. She was constantly broken down, and was not properly equipped, so that she could be held in position against the current. The two propeller tugs were brought out to the Mississippi River on the 10th of October against a terrific current and only water enough in the channel amounting to the bare draft of the tugs, which made it extremely difficult to keep them in the channel. On this day Barbie's Landing gauge read 5.9 feet, the surface of the Mississippi being 7½ feet higher at the mouth of Old River.

The idea that propeller tugs can create or maintain a channel by the scour resulting from their screws over a long shoal is a very serious mistake. The tugs employed were the two very best and most powerful of their size in America, and were worked faithfully twelve hours per day until they were ordered out of Old River, as there was danger from their being so thrown over on one side as to take in water through the engine-room door-way and settle on the bottom, in which case it might have been very costly to get them out, if not a danger of their being lost altogether, with so treacherous a bottom as that of the Lower Old River. On the short, sharp-crested sand-bar at the head of the Atchafalaya Bar, where they were afterwards worked, they did good service, but not without some danger, as the coal-bunkers had to be kept battened down to prevent their taking in water when careened by being forced up on the crest of the bar. The heavy drag-scraper, made up of four 250-pound anchors and the lip of a large dipper dredge, framed together with heavy timbers, and worked over the bow of the stern-wheel boat Gus. Geinn, was very effective in leveling

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off the mud lumps into the deep holes and cutting through the mud-bar at the mouth of Old River. The last boat left the vicinity of the mouth of Red River, with the coal barge in tow, October 12, for New Orleans, where the steamboat was discharged, and the coal barge, with the coal remaining, was safely disposed of. Navigation remained good in Lower Old River until November 27, when the Mississippi had again fallen as low as 7.65 feet on the Red River Landing gauge, and continued falltng until December 2, when it read 7.25 feet, and at the Barbie's Landing guage 3.9 feet. November 27 the United States stern-wheel boat Annie Kelly was got in readiness and left New Orleans for the month of Red River, where the drag-scraper was reframed and placed on the Annie Kelly, and work was resumed in the mouth of Old River November 30, as the examination of the day previous had shown this to be the worst place. There still remained enough of the brush-dams in Chandler's Reach to keep the channel there good.

December 8, navigation being good and the Mississippi rising, the Annie Kelly returned to New Orleans and was laid up. After the hired plant had been dispensed with, October 14, the quarter-boats and skiffs were repaired, and the coal taken out of the old sunken coal-barge; the gauges at West Melville, Simmsport, Barbie's Landing, and the mouth of Old River, were renewed and put in order for the high-water season. The Atchafalaya steamboats Warren and Fanchon kept running all the season; they report fairly what water they find, but reports of such boats as the Phil. E. Chappell, who run into the bank in the dark, tie up for the night, and then report in the papers as delayed in Old River twenty-two hours, "had to pull through," are not to be depended upon as correct. Since December 10 the work has consisted of office work only. A series of maps showing the proposed navigation route from the Mississippi River to the Red and Atchafalaya rivers through Bayou Plaquemine and Grand River have been prepared, consisting of a map of Bayou Plaquemine surveyed 1883; a map showing the whole of the proposed route; a general plan for a double lock at Plaquemine; a map of the Narrows in Grand River, with cross-sections from the survey of 1879; a profile of the center line of the proposed canal through Bayou Plaquemine, with a report on the work required, including the estimates of the cost, as previously presented by you to the Commission.

From March 1, to the present date no work has been done in connection with the improvement of the mouth of Red River, Louisiana. The services of the assistant in charge of the works were dispensed with, the property placed in the care of watchmen, and the quarter-boats and steamer Ruby removed from the mouth of Old River to Giles Bend, above Natchez, for greater economy and safe-keeping.

I am, respectfully, your obedient servant,

ARTHUR OWEN WILSON,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

K 4.

REPORT OF ASSISTANT ENGINEER A. O. WILSON UPON THE PLAQUEMINE ROUTE.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., February 20, 1885.

MAJOR: I have the honor to submit to you the following report, to accompany the maps, plan, and profile made under your direction.

At the meeting of the Mississippi River Commission, held in Saint Louis, Mo., September 14, 1882, the following resolution was passed:

"That Major Stickney, United States Engineers, be requested to submit an estimate of the cost of making a survey of the navigation route from the Mississippi River through the Bayou Plaquemine, and up the Grand and Atchafalaya rivers to the head of the latter stream, with a view to reporting upon the feasibility and cost of improving said route, to replace the present access to Red River."

In accordance with the above, a project for a survey, with an estimate of the cost, was submitted by you, and at a meeting of the Mississippi River Commission, held in New Orleans, March 21, 1883, it was resolved that the project be adopted and recommended.

In accordance with the above resolution of the Mississippi River Commission preparations were made, and a party sent into the field to make a survey of the proposed "navigation route." The survey party went into the field early in June, 1883, the waters of the flood making it impracticable to commence field work any sooner. Owing to the extreme sickliness of the season and the death of Assistant

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Engineer E. A. Szalla, who was in charge of the party, the survey was not carried beyond Bayou Plaquemine.

The canal part and locks, which form all the heavy work in connection with the route, are included in this survey. The survey of 1880–'81, made for the same purpose, of the remaining portion of the route furnishes all the information and data required, and from which the estimate of the widening at the narrow part of Grand River was made.

An estimate of the cost of making a route for navigation from the Mississippi through Bayou Plaquemine and up Grand and Atchafalaya rivers was presented to the Commission by you in December, 1883, appended to which were the reports of Assistant Engineer F. W. Lehnartz on the cost of the excavation in Bayou Plaquemine, and that of Assistant Engineer H. C. Collins on the cost of the locks at Plaquemine and the work required in Grand River.

The following additional, prepared under your direction, are now completed:

A map of the navigation route.

A map of the canal part.

A general plan for a double lock.

A map of the Grand River Narrows.

A profile on the center line of the canal through Bayou Plaquemine.

The map of the navigation route shows all the water-ways, large and small, including the Mississippi and Atchafalaya rivers, from the mouth of Red River to Plaquemine, on the Mississippi, and to Grand Lake.

This map is compiled from the parish maps of Pointe Coupée, West Baton Rouge, and Iberville, including parts of the parishes of Saint Martin's and Ascension, compiled in 1859 from the most authentic United States surveys, and indorsed by J. M. Culloh, Surveyor-General; from a map of the Atchafalaya and Pointe Coupée basins, made by John V. Van Pelt, civil engineer, in May, 1873, and from a map of the Atchafalaya River made from a survey of Assistant Engineer F. P. Leavenworth, under the direction of Maj. C. W. Howell, United States Army, in 1874.

The map is made on a scale of 1 inch to a mile, in order to illustrate the whole route and the character of the country through which it runs.

The map of the canal part, through the Bayou Plaquemine, is made from the survey by Assistant Engineer E. A. Szalla, June to September, 1883. The map shows the proposed location of the canal and the site for the locks in Plaquamine town. The estimate for the excavation is made from the cross-sections of Bayou Plaquemine, on the basis for a channel 150 feet wide on the bottom and a depth of 5 feet at low water, with side slopes of 3 horizontal to 1 vertical, and the curvature limited, to a minimum radius of 1,500 feet on the center line. This map extends over all that part of the bayou requiring enlargement, and is made on a scale of $\frac{1}{6000}$. The map shows the channel, 150 feet wide on the bottom, located as estimated upon by Assistant Engineer F. W. Lehnartz. The general plan for a double lock as estimated upon by Assistant Engineer H. C. Collins.

The plan, as presented, is to show the character of the structure proposed as the most suitable to the locality and adapted to the requirements of navigation. The nature of the ground is such as to require a structure with its weight as equally distributed over the area on which it is built as possible.

The lock-chambers show a length of 300 feet between the gates with a width of 75 feet. The plan provides for a guard-gate at the Mississippi entrance.

The walls of the first chamber will have a height of 40 feet, giving a depth of 6 feet on the floor at low water. The extreme difference between the highest water in the Mississippi and the level of the lowest in Grand River, at the mouth of Bayou Plaquemine, is 32 feet, as stated by Mr. H. C. Collins in his estimate on the cost of the locks, so that the top of the walls will be 2 feet above the highest known flood, with guard-timbers carried 10 feet higher. The walls of the second or lower chamber are to have a height of 25 feet from the floor. This chamber it is proposed to use alone for all stages from low water up to 15 feet, after which and up to extreme high water the upper or first chamber is to be used for the passing of boats up from and down to the lower chamber and the Mississippi at the high stages, or whenever the Grand River shall have attained a stage equal to over 15 feet in the Mississippi River. Only the upper or first chamber will be used. There will be times when the lockage is down into the Mississippi. Provision is made for this in the plan. The gates proposed are of iron; the lock-chambers will be filled through wickets in the gates. It is proposed to make the gates on the general plan of the wheeled gates for Davis Island Dam.

The profile taken on the center line of the canal, as laid down on the map of the canal part.

The profile shows the depths of cutting required on the center line of the canal from the Mississippi through Bayou Plaquemine to its junction with Bayou Grosse Tête, beyond which point navigation is good up to the Narrows in Grand River.

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MAP OF THE GRAND RIVER NARROWS.

This map, with the cross-sections, shows the work required to make this part of Grand River equal in point of navigation to the other portions of the route. The heavy lines on the map and cross-sections indicate the channel 150 feet wide at low water, and the broken lines indicate the 200-feet-wide channel, as estimated for.

This map and cross-sections are made from the survey and examination made in 1880 and 1881 by Assistant Engineer H. C. Collins, who also made the estimate submitted.

The estimates for the navigation route, as presented by you to the Mississippi River Commission in December, 1883, are as follows:

TWO LOCKS.

Brick walls	$531,550 00
Concrete walls (Portland cement)	479,600 00
Concrete walls (Rosendale cement)	401,650 00
Concrete walls (Louisville cement)	384,950 00

EXCAVATION IN BAYOU PLAQUEMINE.

3,557,720 cubic yards, at 20 cents	711,544 00
Contingencies, 10 per cent	71,154 40
	782,698 40

CHANNEL IN GRAND RIVER 200 FEET WIDE, 5 FEET DEEP.

Excavation, 1,257,000 cubic yards, at 20 cents	251,400 00
Grubbing 61 acres, at $75 per acre	4,575 00
Clearing banks 20 miles, at $200	4,000 00
Contingencies, 10 per cent	25,997 50
	285,972 50

CHANNEL IN GRAND RIVER 150 FEET WIDE, 5 FEET DEEP.

Excavation, 631,064 cubic yards, at 20 cents	126,212 80
Grubbing 31 acres, at $75 per acre	2,325 00
Clearing banks 20 miles, $200 per mile	4,000 00
Contingencies, 10 per cent	13,253 78
	145,791 58

REMOVING RAFT AND SNAGS IN ATCHAFALAYA RIVER.

Snag-boat	60,000 00
Two seasons' work, eight months each, at $3,000	48,000 00
	108,000 00

Aggregate cost of route.

Items.	Brick locks.		Concrete locks.	
	Grand River Channel 200 feet.	Grand River Channel 150 feet.	Grand River Channel 200 feet.	Grand River Channel 150 feet.
Locks	$531,550	$531,550	$479,600	$479,600
Bayou excavation	782,700	782,700	782,700	782,700
Grand River	286,000	145,800	286,000	145,800
Removing raft and snags in Atchafalaya River	108,000	108,000	108,000	108,000
Total	1,708,250	1,568,050	1,656,300	1,516,000

I am, very respectfully, your obedient servant,

ARTHUR OWEN WILSON,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

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K 5.

REPORT OF ASSISTANT ENGINEER W. G. PRICE UPON WORK IN NEW ORLEANS HARBOR.

NEW ORLEANS, LA., *May* 18, 1885.

MAJOR: I have the honor to make the following report of work in New Orleans Harbor during the low-water season of 1884.

It having been decided to begin the work of putting down submerged spurs at Gouldsboro', plans, and estimates of material required, were prepared.

Three decked barges were constructed by contract and delivered August 28. The stern-wheel tow-boat Anne Kelly (name since changed to General Newton) was purchased August 23, and was employed in towing barges of rock from Wilson's Point, Louisiana, to Gouldsboro'. The plant in use in Carrollton Bend in 1883 was improved and put in order for the new work. A survey of Gouldsboro' Bend was completed in July. On August 24 the plant was towed to Gouldsboro', and on the 29th the construction of the first spur was begun. The work of constructing and sinking spurs was done by hired labor. The willow brush, lumber, bolts, chains, &c., were delivered by contractors. Stone was purchased at Chester, Ill., by Capt. J. H. Willard, Corps of Engineers, United States Army, and sent down on chartered barges. A small amount of ballast was also purchased in the harbor. Several delays, which increased the cost of the work, were caused by the slow delivery of material by contractors. The mattress for each spur was 200 feet wide up and down stream, and extended 350 feet out in the river. It was woven of willow brush and poles and had iron rods and chains woven in it to give the necessary strength required in sinking it. A narrow crib-work filled with rock was built on the edge round three sides of it.

While sinking the mattresses it was supported on three sides by double lowering lines 1 inch in diameter, placed 16 feet apart, and the shore edge was fastened with iron rods to logs buried in the ground. Each lowering line passed up over the rounded gunwale of a decked barge, then once around a timber head, and was fastened to a messenger rope which was carried round capstan near the shore.

One man payed out the messenger which controlled all the lowering lines so that none were unduly strained. The mattress was held against the current by six large ropes which were fastened to the upper edge by toggles and were carried diagonally up-stream to the bank. The mattress was heavily ballasted round the edges and just enough rock was put elsewhere to put it out of sight, great care being taken not to load it too heavy, then it was lowered to the bottom and more rock thrown on. The ballasting was done entirely from a barge, no rock being wheeled on. In lowering, the up-stream edge was allowed 10 feet start of the down-stream edge, and then they were lowered an even amount till both were on the bottom. On a line parallel with the up-stream edge of the mattress and 70 feet below it there were sunk, one on another, six cribs each 5¾ feet thick. The bottom crib had a width of 60 feet and the top one 22 feet. The bottom crib was short and they increased in length so that the top of the last one was about on a slope of 3 horizontal to 1 vertical from the low-water shore-line, and it extended 300 feet out in the river. The method of sinking the cribs was the same as for as the mattress except that they were heavily ballasted before lowering to the bottom. The spur was built out at right angles to a line drawn tangent to the curve of the bank. The cribs were built on timber-ways on the bank and launched. They consisted of a frame-work made of sawed timbers held together with long iron bolts and wooden posts fastened with wooden pins and filled with willow brush, leaving pockets into which to throw the stone. The mattresses and cribs for two complete spurs and a mattress and three cribs towards another were successfully made and sunk to the correct position without accident.

In sinking the mattress 7 pounds of rock weighed in water was used for each square foot of surface.

In sinking the cribs 7 pounds of rock weighed in water was used for each cubic foot of crib-work.

The average cost of a complete spur, not including cost of plant, was $12,525.

Mattresses with crib-work round edges of them cost 7.6 cents per square foot when ballasted and sunk.

Crib-work of spurs cost 3.6 cents per cubic foot when ballasted and sunk. Experience gained would enable us to greatly reduce the cost of future work of this kind. The work was stopped November 28, the appropriation having been exhausted.

Respectfully submitted.

W. G. PRICE.

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PLATE N°2

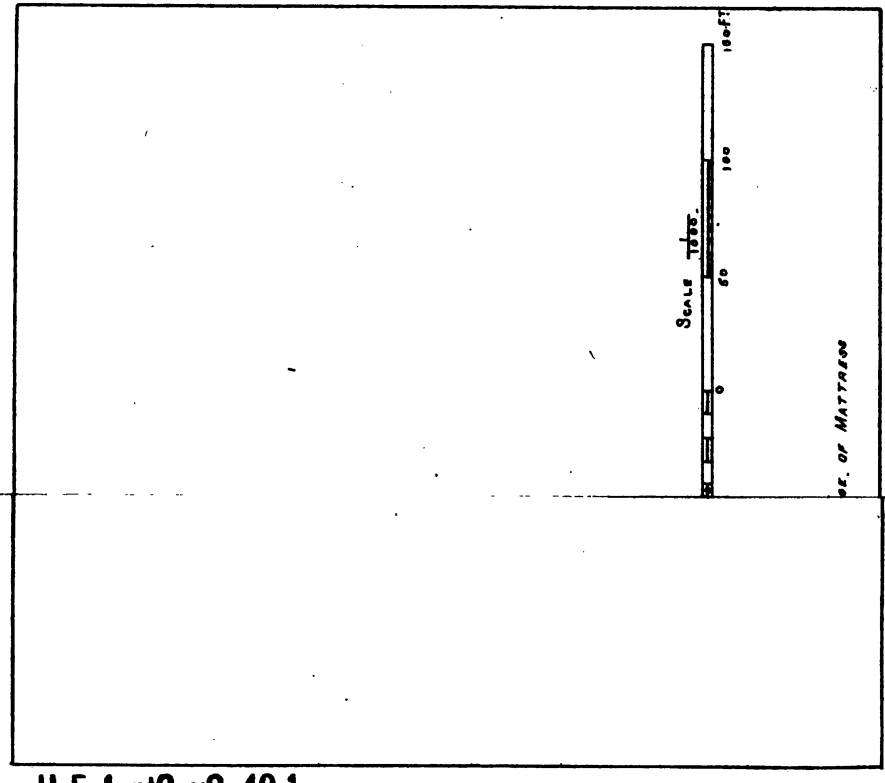

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PLATE Nº 3

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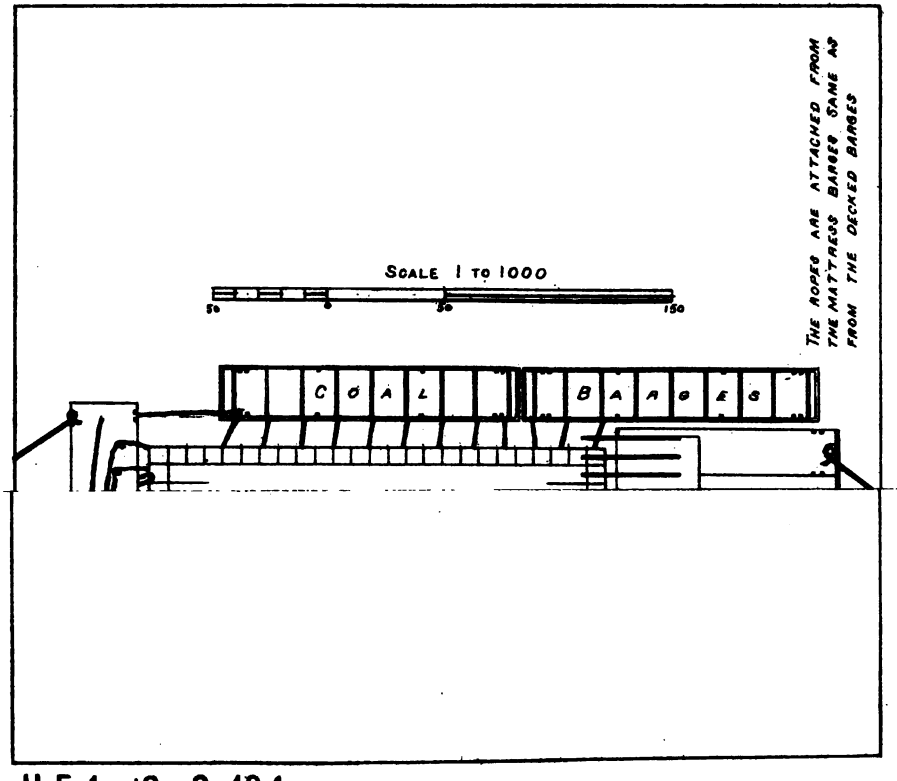
PLATE No. 5



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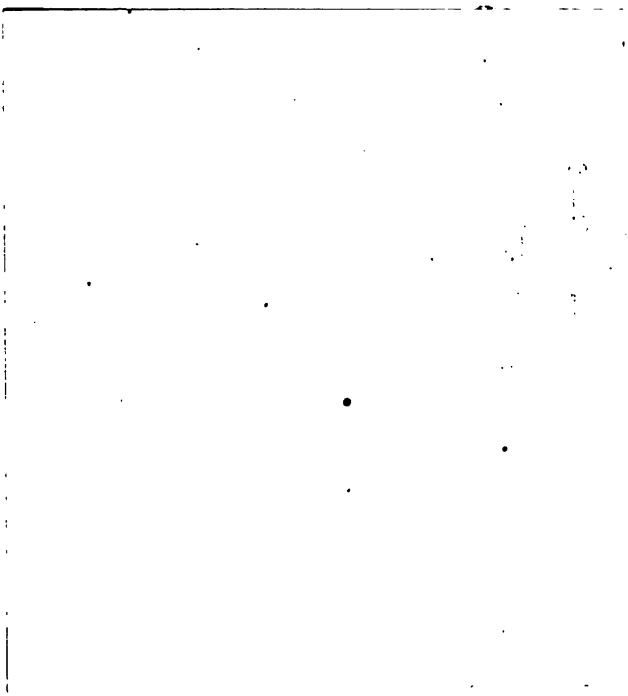

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